PB83-163113

San Francisco Bay Area National Urban Runoff Project. Demonstration of Non-Point Source Pollution Management on Castro Valley Creek: Appendix

Alameda County Flood Control and Water
Conservation District, Hayward, CA

Prepared for

Association of Bay Area Governments
Berkeley, CA

Jun 81

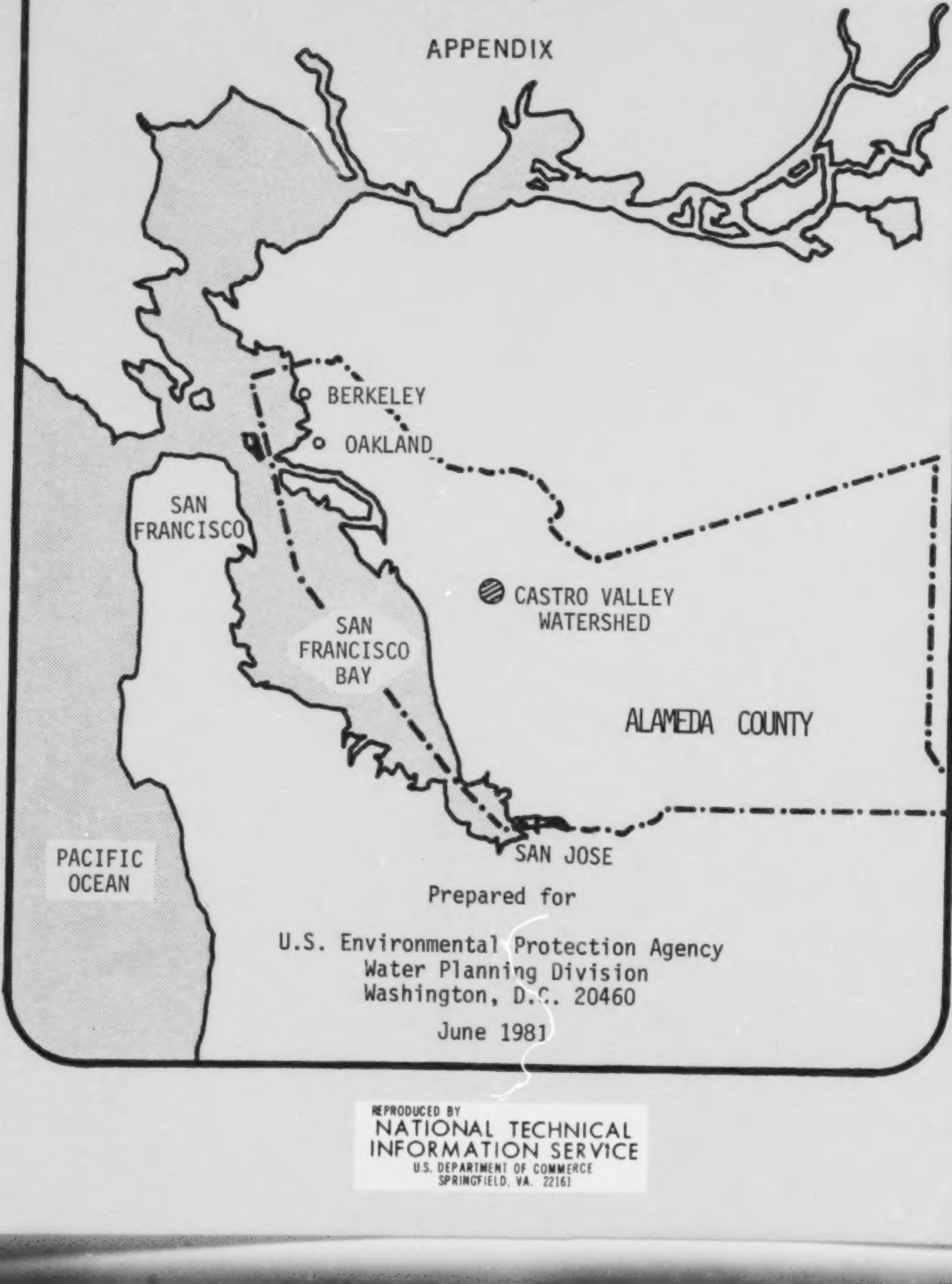
U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-163113

SAN FRANCISCO BAY AREA
NATIONAL URBAN RUNOFF PROJECT

A Demonstration of Non-Point Source Pollution Management on Castro Valley Creek

APPENDIX


BERKELEY
OAKLAND
SAN FRANCISCO
CASTRO VALLEY WATERSHED
SAN FRANCISCO BAY
ALAMEDA COUNTY
SAN JOSE
PACIFIC OCEAN

Prepared for

U.S. Environmental Protection Agency
Water Planning Division
Washington, D.C. 20460

June 1981

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INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO.

2.

3. Recipient's Accession No. PB83 163113

4. Title and Subtitle SAN FRANCISCO BAY AREA NATIONAL URBAN RUNOFF PROJECT - A demonstration of Nonpoint Source Pollution Management on Castro Valley Creek - Appendix

5. Report Date

6.

7. Author(s)

Robert Pitt and Gary Shawley

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Alameda County Flood Control and Water Conservation District
399 Elmburst St.
Hayward, CA 94544

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.

(C)

(G)

12. Sponsoring Organization Name and Address

Association of Bay Area Governments (ABAG)
Hotel Claremont
Berkeley, CA 94705

13. Type of Report & Period Covered

14.

15. Supplementary Notes

One of three volumes: Executive Summary, Main Report, Appendix.

16. Abstract (Limit: 200 words)

This report presents the results and conclusions from an EPA-sponsored nonpoint source pollution management project on Castro Valley Creek in Castro Valley, CA, designed to correlate street cleaning and urban runoff water quality. The study area was a suburban 1,542-acre watershed that is considered typical of many residential basins in the San Francisco Bay region. To demonstrate the relationship between street cleaning and runoff, the project was designed to measure the following: (1) street cleaning effectiveness (2) street surface pollutant loadings and (3) runoff water quality. Data were analyzed to correlate street surface pollutant loadings before rain events with changes in runoff water pollution mass yields. This volume contains nine appendices consisting of the results of most of the field and laboratory data reduced by computation to tables and figures and expanded descriptions of the study area and project design and procedures.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:

No restriction on distribution

19. Security Class (This Report) Unclassified

20. Security Class (This Page) Unclassified

21. No. of Pages 173

22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

SAN FRANCISCO BAY AREA
NATIONAL URBAN RUNOFF PROJECT

APPENDIX

A Demonstration of Non-Point Source
Pollution Management on
Castro Valley Creek

By

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Prepared for

U. S. Environmental Protection Agency
Water Planning Division
Washington, D.C. 20460

June 1981

The preparation of this report, map, document, etc., was financed in part through an areawide waste treatment management planning grant from the Environmental Protection Agency, Region IX, under the provisions of Section 208 of the Federal Water Pollution Control Act as amended. Contract arrangements were made with ABAG.

DISCLAIMER

This report has been reviewed by the Water Planning Division, U.S. Environmental Protection Agency, and the Alameda County Flood Control and Water Conservation District and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

INTRODUCTION TO APPENDIX

The Appendix is made up of nine appendices, A through I. It comprises the results of most of the field and laboratory data reduced by computation to tables and figures. The material contained herein further expands the information and data presented in the Main Report.

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APPENDIX A

DESCRIPTION OF STUDY AREA

Castro Valley is an unincorporated community within Alameda County. The project's study area was a 2.4 sq. mi. portion of this unincorporated area. The Castro Valley Creek branch of the Castro Valley Watershed shown in Figure A-1 was selected as the study area because it was a manageable size.

The study area is 1,542 acres and is predominantly residential, with urban, suburban and rural terrain in the flats and hills bordering San Francisco Bay south of Oakland and north of San Jose. The uppermost portion of the study area is rural with about 633 acres of grass and woodlands that is slowly being replaced by suburban development. The Seaview station monitors water quality and quantity from this essentially rural area. Below this station is the urban test area of about 909 acres. Length of the main creek channel between the rural station (Seaview) and the urban station (Knox) is 2.4 miles.

The majority of the residential land use in the urban area consists of single family housing with lot sizes varying from 5,000 square feet to 10,000 square feet. The estimated residential population density is about 20 people per acre. Residential land use of the 909 acre urban study area occupies about 636 acres (70 percent), commercial land use occupies about 64 acres (7 percent), and the remaining land is about 209 acres (23 percent) of open space and institutional land use. Development along the stream banks in Castro Valley is intense and houses are frequently constructed directly over the existing streambed. Some light commercial areas, more than six schools, and a short portion of Interstate Highway 580 are also in the area.

Topography within the drainage basin is highly variable, and the land slopes range from 10 percent to 70 percent in the upper end of the basin to slopes as low as 1 percent in the valley portion near San Lorenzo Creek. The Castro Valley Creek streambed in the lower portions of the drainage basin range from 20 feet to 50 feet in width and 8 feet to 10 feet in depth. The streambed is often strewn with litter and debris.

Climate of the area is under the marine influence of San Francisco Bay and the Pacific Ocean. The Mediterranean climate is characterized by a dry summer followed by a wet winter with irregularly spaced, frontal rainstorms. Normal annual rainfall is about 21 inches with over 90 percent usually occuring between October and April. Precipitation intensity rarely exceeds 2.6 inches in 24 hours. Snowfall is rarely observed. In a normal rainfall year, there are about 63 days of measurable rainfall. Prevailing winds are from the west to northwest with the strongest winds (to 40 m.p.h.) usually associated with winter storms.

The study area is underlain with alternating sequences of sandstone and mudstone with locally thick lenses of conglomerate. Compositionally, the sandstones are primarily quartz, feldspar and biotite. The conglomerate is mantled by deeply weathered shale and soft, crumbly, clayey soil. The soils are composed of the Las Oras and Millsholm types where texture is basically a silt loam.

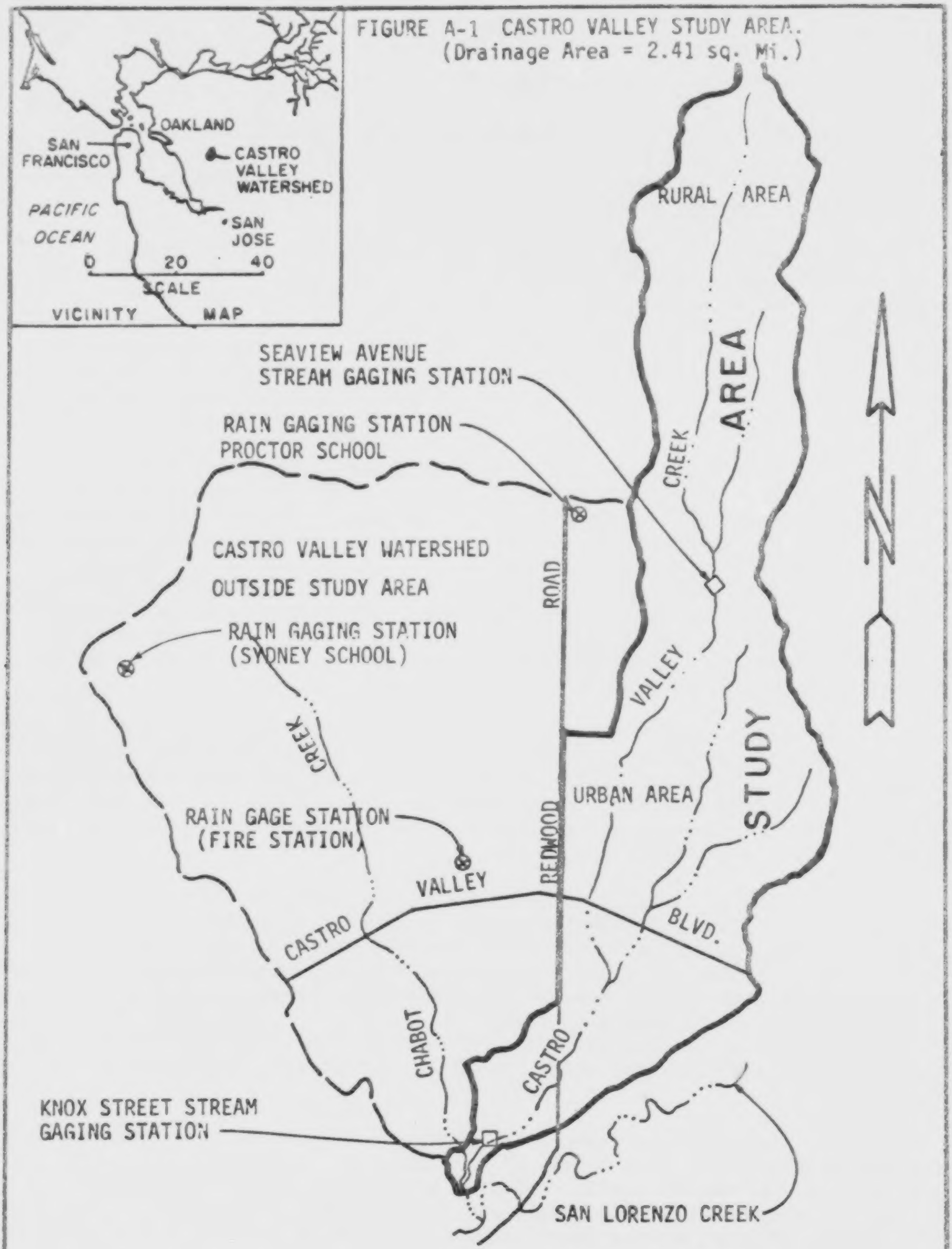

FIGURE A-1 CASTRO VALLEY STUDY AREA.
(Drainage Area = 2.41 sq. Mi.)

OAKLAND
SAN FRANCISCO
CASTRO VALLEY WATERSHED
PACIFIC OCEAN
SAN JOSE
0 20 40
SCALE
VICINITY MAP
RURAL AREA
STUDY AREA
SEAVIEW AVENUE STREAM GAGING STATION
RAIN GAGING STATION PROCTOR SCHOOL
CASTRO VALLEY WATERSHED
OUTSIDE STUDY AREA
RAIN GAGING STATION (SYDNEY SCHOOL)
CREEK
VALLEY
ROAD
REDWOOD
URBAN AREA
RAIN GAGE STATION (FIRE STATION)
CASTRO VALLEY BLVD.
CHABOT
CASTRO
KNOX STREET STREAM GAGING STATION
SAN LORENZO CREEK
N
SCALE: 1"= 2000'±

Hydrologic Features

Important aspects of the project were dependent on rainfall and resultant runoff. The normal annual rainfall in Castro Valley is about 21 inches. In a normal rain year, there are about 63 days of measurable rainfall (precipitation greater than 0.01 inches). During the project's data collection, October, 1978 to April, 1980, about 20 inches of rain was measured per year with about 60 days per year of rainfall.

Two Stevens continuous recording stream gages were installed and operated by USGS and two automatic ISCO water samplers flow meters and punters were installed and operated by Alameda County Flood Control and Water Conservation District on Castro Valley Creek. The upper gaging station, USGS #11181004, is located at Seaview Street and measured runoff from the relatively undeveloped portions of the study area. The lower gaging station, USGS #11181006, is located at Knox Street and measured the runoff from the urbanized section in addition to the upper undeveloped portion of the study area. Runoff from the urban test area only is determined by subtracting the runoff of the rural station from the urban station. For rainfall measurements, a USGS weighing bucket rain gage (USGS No. 374259122041901) located at Proctor School was used. The Corps of Engineers monitored runoff at another station about 300 feet downstream from the Knox Station at the confluence of Chabot and Castro Valley Creek.

San Lorenzo Creek, downstream of the confluence of Castro Valley and Chabot Creeks, is a large watercourse with contiguous urban development. This creek carries the flow to its discharge point into San Francisco Bay.

Castro Valley was chosen as the study area for the following reasons:

1. Castro Valley Creek is not affected by either municipal or industrial point sources.
2. Castro Valley Creek is a small stream transversing a well defined suburban area; its upstream waters pass through a relatively undeveloped area.
3. Castro Valley watershed is representative in terms of land use and land surface characteristics of residential watersheds within the San Francisco Bay-Delta region.
4. The existing, usable storm runoff management data base on the entire Castro Valley watershed is extensive (e.g., receiving water quality values for about 30 rain events, plus some dry weather measurements, applications of state-of-the art stormwater models, i.e., applications of the SWMM model for quantity and quality, published estimates of structural management cost and effectiveness values, street surface pollutant accumulation rates, and street cleaner cost and effectiveness values.)

5. Many western cities discharge into similar small receiving waters and a demonstration of non-point source water pollution abatement through improved management practices may provide the ability to prescribe effective, implementable control plans from cost, technical and political viewpoints for other similar watersheds.

During the first year analysis the study area was divided into four sub-areas (Figure A-2) These horizontal divisions across the watershed were based on topography and street patterns. Land use in the uppermost portion of the watershed (i.e., at the headwaters) is rural, with grass and woodlands slowly being replaced with suburban residential development. This largely open-space portion has the most topographic relief of any of the four sub-areas. The adjacent (upper urbanized) sub-area is primarily suburban residential with one school. There are observable income differences of the households in this upper urban sub-area compared to the two lower urban sub-areas. This higher income sub-area is characterized by slightly larger lot sizes, slightly newer homes, the lowest percentage of low income single family homes, and a larger amount of mixed, deciduous-evergreen landscaping adjacent to the street. The predominant characteristics of this area are the larger portion of higher income single-family homes, a smaller density of on-street parked cars and steep topography. The middle urban sub-area's major difference, when compared to the other urban sub-areas, is a larger percentage of asphalt gutters. There are three schools, some lower income single family homes, and a fair amount of commercial land use in this sub-area. The topography is moderate. The lower urban sub-area is primarily flat with the largest percentage of lower-income single-family homes, two schools and some multiple family housing. The primary difference among the four areas, therefore, is topographic relief.

There are many similarities in the three lower urban sub-areas (Table A-1). The three most obvious are the types of gutters, the shapes of the curbs and the condition of the street surfaces. Seventy-five percent of the gutters are concrete and 25 percent are asphalt. The configuration of the curb (straight or rolled) may influence how much of the street surface contaminants are kept within the gutter and thus are available to the street cleaners, and how much is transported to the shoulder of the road and not available for pickup by normal street cleaner operation. The condition of the street surfaces is a major determinant of the accumulation rate of street surface contaminants and performance of street cleaning equipment: 91 percent of the street surfaces in the lower three urban test areas are in fair condition, with little variability in condition or width (96 percent of the streets in these sub-areas are 20 feet to 40 feet wide).

A variable that may significantly influence the quantity of nutrients that may be removed by street cleaning operations is the amount of leaf material on the streets. The largest accumulation of leaves on the streets is in the middle urban sub-area, but this difference does not appear to be significant. Two important variables that influence the effectiveness of the rain-flushing of particulates from the street surface are speed of the traffic and density of the traffic. These two variables are also very similar for the three urban sub-areas.

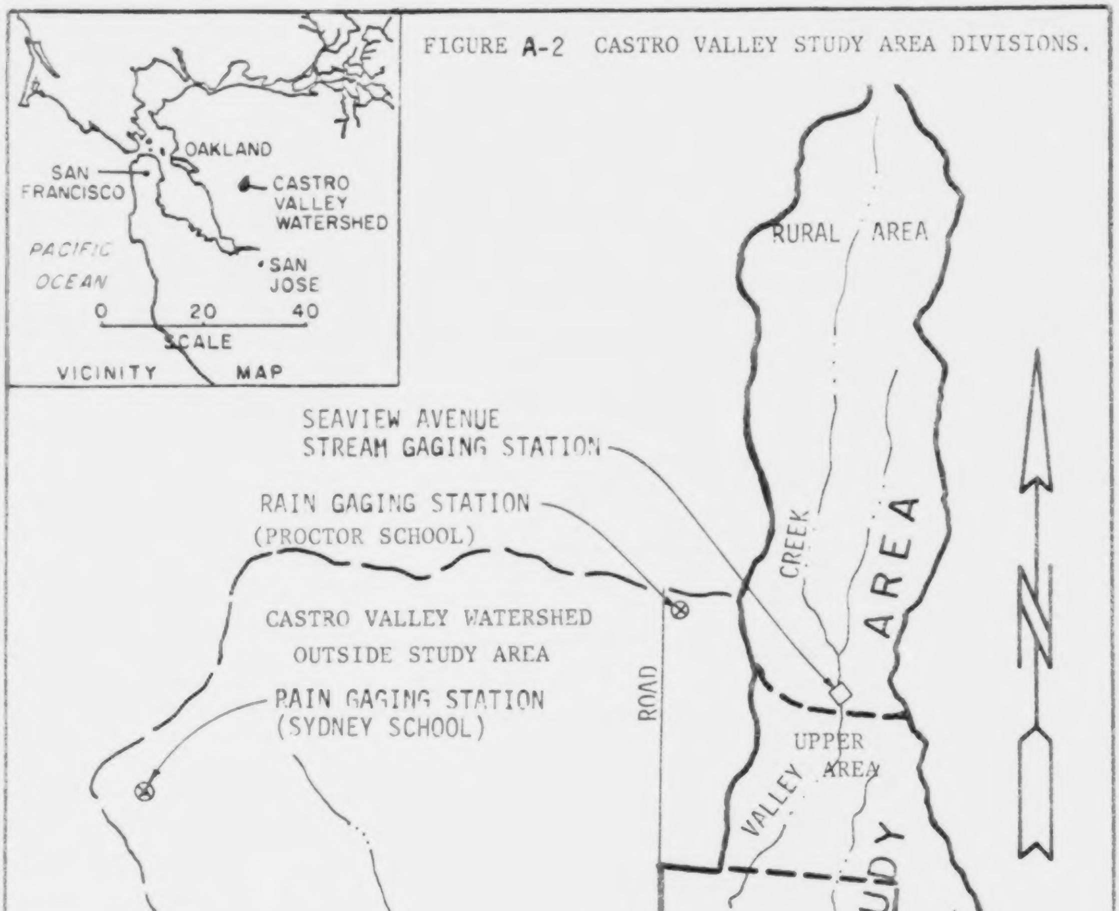
SAN FRANCISCO
OAKLAND
CASTRO VALLEY WATERSHED
PACIFIC OCEAN
SAN JOSE
0
20
40
SCALE
VICINITY MAP
SEAVIEW AVENUE STREAM GAGING STATION
RAIN GAGING STATION (PROCTOR SCHOOL)
CASTRO VALLEY WATERSHED OUTSIDE STUDY AREA
RAIN GAGING STATION (SYDNEY SCHOOL)
RAIN GAGE STATION (FIRE STATION)
RURAL AREA
CREEK
VALLEY
STUDY AREA
UPPER AREA
URBAN AREA
MIDDLE AREA
LOWER AREA
ROAD
REDWOOD
CASTRO VALLEY BLVD.
CASTRO
KNOX STREET STREAM GAGING STATION.
SAN LORENZO CREEK
N
SCALE: 1"= 2000'±

FIGURE A-2 CASTRO VALLEY STUDY AREA DIVISIONS.

TABLE A-1 URBAN TEST AREA CHARACTERISTICS (PERCENT, UNLESS OTHERWISE NOTED)
DRAINAGE AREA = 909 ACRES

	LOWER	MIDDLE	UPPER	TOTAL
Number of Gutters				
0	0	0	0	2
1	0	0	11	4
2	100	89	89	92
4	9	5	0	2
Gutter Type				
Concrete	93	62	78	76
Asphalt	7	38	17	22
Mixed	0	0	5	2
Gutter Shape				
Straight	0	0	5	2
Rolled	41	52	69	55
Mixed	59	48	26	43
Median Strip				
Yes	0	5	0	2
No	100	95	100	98
Street Condition				
Poor	0	0	3	1
Fair	74	97	97	91
Good	26	3	0	8
Street Width				
20 to 40 feet	93	95	100	96
40 feet	7	5	0	4
Landscaping Type				
Deciduous	78	74	46	65
Evergreen	11	5	0	5
Mixed	11	21	54	30
Landscaping Quantity				
None	11	0	0	3
Some	85	89	91	89
Much	4	11	9	8
Leaves on Street				
Few	81	74	43	65
Some	15	21	45	28
Much	4	5	12	7
Parking Density				
None	4	2	0	2
Light	55	50	89	65
Moderate	37	42	11	30
Heavy	4	6	0	3

TABLE A-1 URBAN TEST AREA CHARACTERISTICS (PERCENT, UNLESS OTHERWISE NOTED)
DRAINAGE AREA = 909 ACRES (continued)

	LOWER	MIDDLE	UPPER	TOTAL
Street Density				
Lane miles/acre	-	-	-	.06
Portion of Streets w/curbs & gutters	-	-	-	90
Traffic Density				
Light	79	63	77	72
Moderate	7	26	23	20
Heavy	14	11	0	8
Traffic Speed				
25 MPH	52	39	40	43
25 - 40 MPH	48	58	60	56
40 MPH	0	3	0	1
Topography				
Flat	66	39	3	34
Slight	30	34	3	22
Moderate	4	11	37	18
Moderate/Steep	0	3	11	5
Steep	0	13	46	21
Land Use				
Residential				70
Commercial				7
Other (Schools, Vacant, Open Space)				23
Street Surface Particulate Loadings				
Mean (lbs/curb-mile)	369	675	563	552
Median (lbs/curb-mile)	321	536	467	432
Standard Deviation (lbs/curb-mile)	219	540	363	425
Standard Deviation/Mean (ratio)	0.59	0.80	0.64	0.77
Minimum (lbs/curb-mile)	48	100	82	48
Maximum (lbs/curb-mile)	821	2970	1260	2970
Number of Valid Data Points	27	37	34	98

Average daily traffic (ADT) volumes for the two major arterial streets in the study area are 24,000 for Castro Valley Boulevard which runs north to south and serves as the border between the lower and middle sub-areas; and 19,500 for Redwood Road which is aligned west to east and serves as the northern border of the lower and middle sub-areas ADT volumes for the seven collector streets are about 3,500 for the entire urban test area. ADT volumes for the minor residential streets of the urban study area are 1,000.

Normal street cleaning practice in the study area consists of one pass with a mechanical brush type sweeper at intervals of once about every seven weeks in the residential area (49.2± curb miles) and once per week along Castro Valley Boulevard, the major arterial and commercial strip (2.5 curb miles). There are no special parking restrictions in the study area related to street cleaning activities.

The study area has drop inlets and not catch basin structures. These are cleaned about once per year with a shovel and bucket or a vacuum unit. Leaf disposal is a part of the routine street cleaning effort. Usually twice per year, after major leaf fall, the County Road Department sends in special pieces of equipment to reduce the amount of leaves to be removed by the street cleaners. Residential garbage is collected weekly.by a disposal company.

The Castro Valley Creek branch of the Castro Valley watershed was selected as the study area in order to reduce the study areas to a more manageable size (from 5.6 square miles to 2.4 square miles). The other major reason the Chabot Creek branch of the Castro Valley watershed was not included as part of the study area was that it was advised that it could not be used as a control area because similarities between the two areas had not been proven. Calibration of the areas was not attempted because of insufficient funds in the project budget and expected inaccuracies.

APPENDIX B

EXPERIMENTAL DESIGN, FIELD AND LABORATORY PROCEDURES AND INSTRUMENTATION

The following appendix describes the results of the experimental design and the field sampling procedures used to gather the street surface and receiving water samples. Also described is the quality control in the form of the sampling and calculation sheets and the laboratory procedures and references for the street dirt chemical analysis.

RESULTS OF EXPERIMENTAL DESIGN TESTS

Street surface samples were collected from narrow strips that were the width of the street. The analytical procedure used to determine the number of sub-samples needed involved weighing individual sub-samples in the study area to calculate the standard deviations (σ) and the means ($\bar{x}$) of street surface loading values.

From these two values, the number of sub-samples necessary (N), depending on the allowable error (L), were determined. An allowable error value of about 25 percent, or less, was used.

The formula used (Cochran 1963) was:

$$N = 4\sigma^2/L^2$$

With a 95 percent confidence limit, this formula determines the number of samples needed to determine the true value for loading within a range of + L. Initially, individual samples were taken at 100 locations in the three urban study areas to determine the loading variability. Loading varied within the study area but the median values in the three test areas were fairly close. The overall minimum loading was about 50 lbs/curb-mile, the overall maximum value was about 3,000 lbs/curb-mile, and the overall median value was about 400 lbs/curb-mile. The median values in the three areas were about 320, 540, and 470 lbs/curb-mile.

Preliminary statistical analyses (using Student "t" tests) showed little loading variations between candidate sub-division groups. The topographical grouping was made for sampling convenience, as it was difficult to sample the complete study area twice in a single day (as required for the street cleaning tests). The relative variations of particulate loadings within the three test areas did vary. During the second year, the complete study area was tested as a unit to maximize the street particulate loading value range.

The study area configuration for the second year was different than what was used in the first year in order to maximize the overall range of street surface loading conditions at any one time. The first year's program resulted in data allowing comparison of three different sub-study areas. These sub-areas were differentiated on a basis of topography. The lower study area was generally flat and had the dirtiest streets and had some commercial land uses. The middle study area was of flat to moderate slope and was mostly residential, while the upper study area was moderate to steep in topography and was also mostly residential. The middle and upper test areas had about the same observed street surface loading conditions. The necessary street cleaning program used during the first year would not allow all three study areas to be sampled and cleaned and sampled again in one day. Therefore, the street cleaning was conducted in each test area on a rotating basis. This resulted in some of the study areas being significantly cleaner than others at any one time. Therefore, the total study area was never at its absolutely cleanest condition, but the total study area did approach the maximum worst case loading conditions. The second year street cleaning program was modified to combine the three test areas. This increased the overall range of street surface loading conditions over what was previously analyzed. This change resulted in the complete study area kept clean for about one month at intermediate values.

Each of the street surface samples were logged in and physically analyzed using appropriate quality assurance techniques and logging form. Each of the samples were weighed, dried and divided into 8 particle sizes using mechanical sieving techniques to determine the per mile unit weights and percentage distribution of the samples for the various particle sizes. These divided samples were then retained and composited for various chemical analyses. Total solids, lead and zinc were given the highest priority. Approximately 24 composited samples made up of the complete study area for a 3 month period and for each of the particle sizes were analyzed for these parameters. Special asbestos analysis on selected bulk samples were also conducted in conjunction with the special asbestos study task.

Only one level of street cleaning effort was monitored in the second year. This involved cleaning the streets every weekday throughout the study area for a period of about 4 weeks. After the first several days of this cleaning program, the streets were as clean as they were likely to be with street cleaning. Therefore, more than 3 weeks occurred during which monitored rains were affected by the lease quantity of street surface contaminants as possible. This month of extensive street cleaning was followed by 2 months of no street cleaning. Approximately one month without any street cleaning was necessary before the streets were as dirty as they were likely to be. The second month of no street cleaning therefore represented the dirtiest street surface conditions.

Street surface loading values tend to level off with minimal increases in street surface loading conditions because of increased fugitive dust losses from the street surfaces from winds and traffic turbulence. Therefore, even though the water pollution potential of the street surface contaminants will not increase beyond this state, the potential air pollution problems associated with fugitive dust losses from the street surfaces will increase. These air pollutant losses can be estimated by observing the deposition and accumulation rate curves to be generated based on the street surface pollutant accumulation measurements.

The two months selected for the extensive street cleanings were November of 1979 and February of 1980. Thos of these months have moderate to heavy rains. December of 1979 and January of 1980 were also months of relatively heavy rainfall. March and April of 1980, following the February period of extensive street cleaning also contained some monitored rain events for comparison with intermediate street surface loading conditions.

A special street cleaning performance evaluation was made using a regenerative air street cleaner. This street cleaner had never been sufficiently tested in other street cleaning demonstration projects. These special tests were conducted between December 3 and December 21, 1979. Approximately 6 sites were selected outside, but adjacent to, the study area. Each site was several (3 to 5) blocks long and was selected to represent the range of conditions encountered in the study area. Each site, however, had homogeneous conditions within themselves and both sides of the streets were similar. Approximately 15, one-half street sub-sampling strips were collected at each site site before and after the equipment operation. The tests involved sampling each side of the street independently in each of the small test areas, and operating a regenerative street cleaner on one side of the street and a mechanical street cleaner on the other side of the street simultaneously. It is also important that parked car counts be noted for each side of the street. Each of the 6 sites were sampled 5 times over a period of about two weeks. Therefore, each site was cleaned about every other day. The initial cleanings involved dirty streets while the cleaning periods near the end represented very clean street surface conditions. Approximately 120 samples were collected from these sites and were mechanically separated and weighed. No chemical analysis were conducted on these special samples.

EXAMPLE CALCULATIONS TO DETERMINE POUNDS PER CURB MILE, MEDIAN PARTICLE SIZE AND STORM MASS EMISSIONS

There were three particular conversions that were used in order to transform the field data into a usable format. These conversions were for computing (1) pounds of street surface particulates per curb mile, (2) median particle size of street surface particulates, and (3) mass emissions of storm runoff pollutants.

The following factors and formulae were used to make the computations:

1. Pounds (of street surface particulates) per curb mile:

$$\left(\frac{\text{gm}}{\text{area}} \times \frac{\text{lb}}{\text{454 gm}}\right) \div \left(\frac{\text{\# of sites}^{a}}{\text{area}} \times \frac{\text{6 curb in.}^{b}}{\text{site}} \times \frac{\text{ft.}}{\text{12 in.}} \times \frac{\text{mile}}{\text{5280 ft.}}\right)$$

= Factor to multiply gms of street sample per area to convert to lbs/curb mile

Where;

a. # of sampling sites per area:
20 in the lower area
36 in the middle area
25 in the upper area
51 in the Total area (second year).

b. Each sampling site was 6 curb inches wide (width of "gobbler").

Example for lower area:

$$\left(\frac{\text{gm}}{\text{area}} \times \frac{1}{454}\right) \div \left(20 \times 6 \times \frac{1}{12} \times \frac{1}{5280}\right) = 1.16\ \frac{\text{gm}}{\text{area}} = \text{lbs/curb mile}$$

	Factors Used
Lower area (20 sites)	1.16
Middle area (36 sites)	0.65
Upper area (25 sites)	0.93
Total Area (second year) 51 sites	0.46

2. Median Particle Size (of street surface particulates)

$$\left(\frac{50-E}{F}\right) R+L = MPS$$

Where E = cumulative percent less than 50% adding from smallest to largest particle size.
F = percent in which median particle size group falls.
R = range of particle size of the median particle size group.
L = lower limit of median particle size group.
MPS = median particle size.

Sieve Size	Range	% of Sample in size range	Cumulative %
6370u	(0)	0.9	100.0
2000-6370u	4370u	13.0	99.1
850-2000u	1150u	5.8	86.1
600-850u	250u	4.9	80.3
(L)250-600u	350 (R)	26.9 (F)	75.4
106-250u	144u	27.0	48.5 (E)
45-106u	61u	16.3	21.5
0-45u	45u	5.2	5.2
	Tot.	100%	

Ranges calculated by subtracting lower sieve. size from larger sieve size in each sieve size group.

Example Calculation:

$$\left(\frac{50-48}{26.9} \times 350\right) + 250 = \underline{\underline{276}} \text{ microns for median particle size}$$

3. Mass Emissions (of storm runoff pollutants)

Purpose: to convert concentrations of pollutants reported in units of mg/l and ug/l to lbs of pollutant per storm.

$$ME = V(\text{ft}^3/\text{storm}) \times C\ (\text{mg/l or ug/l}) \times \frac{7.48 \text{ gal.}}{\text{ft}^3} \times \frac{3.79 \text{ l}}{\text{gal.}} \times \frac{\text{lbs}}{454{,}000 \text{ mg or } 454{,}000{,}000 \text{ ug}}$$

$$ME = V \times C \times \begin{matrix}(6.24 \times 10^{-5} \text{ for C in mg/l}) \\ (6.24 \times 10^{-8} \text{ for C in ug/l})\end{matrix}$$

Where V = volume of storm flow (in cubic feet)
C = flow weighted concentration of pollutant (in mg/l or ug/l)
ME = mass emissions (in lbs. of pollutant)

Conversion from Mg/l of Pollutant to Mg/Kg of Total Residue

$$\frac{\text{mg/l of pollutant}}{\text{mg/l of total residue}} \times \frac{1{,}000{,}000 \text{ mg}}{1 \text{ Kg}} = \text{mg of Pollutant/Kg of Total Residue}$$

STREET SURFACE PARTICULATE SAMPLING PROCEDURES

The sampling procedures described in this appendix have been used in similar studies. These procedures are intended to maximize the accuracy and completeness of the information from the sampling program. Past testing has shown that the vacuum units used can effectively remove much (99 percent of the solids) of the street surface contaminants.

EQUIPMENT DESCRIPTION

A light-duty (half-ton capacity) trailer is used to carry the generator, tools, fire extinguisher, vacuum hose and wand, and two wet-dry vacuum units during sample collection. A truck with a suitable hitch and signal light connections is used to pull the trailer. The truck also has warning lights, including a roof top flasher unit. The truck operates with its headlights and warning lights on during the entire period of sample collection. The sampler and hose tender both wear orange, high-visibility vests. The trailer is equipped with a caution sign on its tailgate.

Both the truck and the street cleaner used to clean the test areas are quipped with radios (CB radios are adequate), so that the sampling team can contact the sweeper operator when necessary. Two-horsepower (hp) industrial vacuum cleaners with one secondary filter and a primary dacron filter bag were selected. The vacuum units are heavy duty and made of stainless steel to prevent contamination of the samples. Two 2-hp vacuums are used together by using a wye connector. This combination extended the useful length of the 1.5 in. vacuum hose to 35 ft. and increased the suction so that it was adeqquate to remove all particles of interest from the street surface. A wand and a gobbler* attachment are also needed. The generator used to power the vacuum units is of sufficient power to handle tne electrical current load drawn by the vacuum units - about 5000 watts for two 2-hp vacuums. Finally a secure, protected garage is used to store the trailer and equipment near the study area when not in use.

SAMPLING PROCEDURE

Two people are required for sampling at all times - one acting as the sampler, the other acting as the vacuum hose tender and traffic controller. Two people lessen individual responsibility, enabling both persons to be more aware of traffic conditions.

Sample collection does not begin before sunrise, nor continue after sunset unless additional personnel are available for traffic control. The street surfaces are also more likely to be dry during daylight hours, which is necessary for good sample collection.

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* The gobbler attaches to the end of the wand and is triangular in shape and about 6 inches across.

Equipment is checked before each day of sampling. The generator's oil and gasoline levels must be adequate. Vacuum hose, wand and gobbler must also be in good condition. The vacuum units need to be clean, and their electrical cords have to be securely attached to the generator. The trailer lights and warning lights also need to be fully operable.

The generator requires about 3 to 5 minutes to warm up, after which the vacuum units are turned on one at a time (about 5 to 10 seconds apart to prevent excessive current loading on the generator). The amperage and voltage meters of the generator are also periodically checked.

Each subsample includes all of the street surface material that would be removed during a severe rain (including loose materials and caked-on mud in the gutter and street areas). The location of the subsample strip is carefully selected to ensure that it has no lected through the middle of a pile of leaves. It is collected where the leaves are lying on the street in their normal distribution pattern. When possible, wet areas are also avoided. If a sample is wet and the particles caked around the intake nozzle, the caked mud from the gobbler is carefully scraped into the vacuum hose while the vacuum units are running at the end of the sampling period.

Each subsample is collected in a narrow strip about 6 in. wide (the width of the gobbler) from one side of the street to the other (curb to curb). In heavily traveled streets where traffic is a problem, some subsamples consist of two separate one-half street strips (curb to crown). Traffic is stopped for subsample collection; the operator sometimes waits for a suitable traffic break. On busy roadways with no parking and good street surfaces, most particulates are found within a few feet of the curb, and a good subsample is collected by vacuuming two adjacent strips from the curb as far into the traffic lanes as possible. A sufficient break in traffic allows a subsample to be collected halfway across the street.

Subsamples taken in areas of heavy parking are collected between vehicles along the curb, as necessary. The sampling line across the street does not have to be a continuous line if a parked car blocks the most obvious and easiest subsample strip. A subsample can be collected in shorter strips provided that the combined length of the strip is equal to the cross-the-street width, and that each strip is representative of a different distance from the curb. Again, in all instances, each subsample is representative of the overall curb-to-curb loading conditions.

When sampling, the leading edge of the gobbler is slightly elevated above the street surface (1/8 in.) to permit pebbles and large particles to enter. The gobbler is lifted to accept larger material as necessary. A large accumulation of leaves in the subsample strip is manually picked up and placed in the sample storage container in order to prevent the hose from clogging. If a noticeable decrease in sampling efficiency is observed, the vacuum hoses are cleaned immediately by disconnecting the hose lengths, cleaning out the connectors (placing the debris into the sample storage container), and reversing the air flows in the hoses (blowing them out by connecting the hose to the vacuum exhaust and directing the dislodged debris into the vacuum inlet). If any mud is caked on the street surface in the subsample strip, the operator loosens it by scraping a foot along the subsample path (being certain that street construction material is not removed from the subsample path unless it is very loose). Scraping caked-on mud is done after an initial vacuum pass. After scraping is completed, the strip is revacuumed. A rough street surface is sampled most easily by pulling the wand and gobbler toward the curb (not by pushing). Smooth and busy streets are usually sampled with a pushing action.

An important aspect of the sample collection is the speed at which the gobbler is moved across the street. A very rapid movement significantly decreases the amount of material collected. Too slow a movement requires more time than is necessary. The correct movement rate depends on the roughness of the street and the amount of material on it. When sampling a street that has a heavy loading of particulates or a rough surface, the wand can travel at a velocity of less than one foot per second. In areas of lowerloadings and smoother streets, the wand can travel at a velocity of 2 or 3 feet per second. The best indication of the correct collection speed is made by a visual determination of how well the street is being cleaned in the sampling strip and by listening to the collected samples rattling up the wand and through the vacuum hose. The ovjective is to remove everything that is lying on the street that could be removed by a significant rainstorm. It is quite common to leave a visually cleaner strip on the street where the subsample is collected, even on streets that appear to be clean.

In all cases of subsample collection, the sampler and hose tender continuously watch for oncoming vehicles. While working near the curb, out of the traffic lane (an area of high loading), the sampler monitors the performance of the gobbler visually. In the street he constantly watches traffic (in both directions), and monitors the collection process by listening to particles moving up the wand. A large break in traffic is required to collect dust and dirt from street cracks in the traffic lane, because the sampler has to watch the gobbler to make sure that all of the loose material in the cracks is removed.

The hose tender always watches for traffic. He also plays out the hose to the sampler as needed, and keeps the hose as straight as possible to prevent kinking. If a kink develops, sampling stops until the hose tender straightens the hose.

When moving from one subsample location to another, the hose, wand, and gobbler are securely placed in the trailer. The hose is placed so as not to touch the generator's muffler, which can burn a hole in it. The generator and vacuum units are left on and in the trailer during the entire subsample collection period.

The length of time it takes to collect the subsamples varies with the number of subsamples and the test area. For the first phase of this study, the test areas require the number of subsamples and sampling periods shown below:

Test Area	No. of Samples	Sampling Period
Lower urban areas	20	1.5 hr.
Middle urban areas	36	2.0 hr.
Upper urban areas	25	1.5 hr.

Several hundred grams of sample material are needed for the laboratory test. An after-cleaning subsample is not collected from exactly the same location as the before-cleaning subsample. They are taken from the same general area, but at least a few few apart.

A field-data record sheet (see Figure B-6) is kept for each sample. It contains:

- o Subsample numbers
- o Dates and time of the collection period
- o Any unusual conditions or sampling techniques

Subsample numbers are crossed off as each subsample is collected. After cleaning, subsample numbers are specially marked if the street cleaner operated next to the curb at that location. This differentiation enables the effects of parked cars on street cleaning performance to be analyzed.

SAMPLE TRANSFER

After all subsamples for a test area are collected, the hose and wye connections are cleaned by disconnecting the hose lengths, reversing them, and holding them in front of the vacuum intake. Leaves and rocks that may have become caught are carefully removed and placed in the vacuum can. The generator is then turned off. The vacuums are either emptied at the last station or at a more convenient location.

To empty the vacuums, the top motor units are removed and placed out of the way of traffic. The otp of the generator is a good location to store them. The vacuum units are then disconnected from the trailer and lifted out. The secondary, coarse vacuum filters are removed from the vacuum can and, using a small whisk broom, are carefully brushed into a large funnel placed in the storage can. The primary dacron filter bags are kept in the vacuum cans and shaken carefully to knock off most of the filtered material. (The hose inlet is blocked with a leg or knee and the primary filter bag is held onto the drum with arms and chest.)

The dust inside the can is allowed to settle for a few minutes, then the primary filter is removed and brushed carefully into the sample can with the whisk broom. Any dirt from the top part of the bag where the bag is bent over the top of the vacuum, is also carefully removed and placed into the sample can.

After the filters are removed and cleaned, one person picks up the vacuum can, while the other person carefully brushes the inside of the vacuum can with a soft 3 or 4-in. paint brush to remove the collected sample. In order to prevent excessive dust losses, the emptying and brushing is done in areas protected from the wind. To prevent inhaling the sample dust, both the sampler and the hose tender wear mouth and nose dust filters while removing the samples from the vacuums.

To reassemble the vacuum cans, the primary dacron filter bag is inserted into the top of the vacuum can with the filter's elastic edge bent over the top of the can. The secondary, coarse filter is placed into the can, then assembled on the trailer. The motor heads are then carefully replaced in the vacuum cans, making sure that the filters are on correctly and the excessive electrical cord is wrapped around the handle of the vacuum unit. The vacuum units are then secured to the trailer with an elastic shock cord. The vacuum hoses and wand are atttached so that the unit is ready for the next sample collection.

The storage cans are labeled with the date, the test area's name, and an indication of whether the sample is taken before or after the sweeping test or is an accumulation (or other type of) sample. Finally the lids of the sample cans are taped shut and transported to the laboratory for analysis or storage.

CASTRO VALLEY CREEK MONITORING PROCEDURES

The goal of the monitoring task was to provide water quality data for the Castro Valley Demonstration Project, and to develop a water quality data base for Castro Valley Creek.

It was important periodically to have personnel at the sampling sites to oversee the operation of the automatic samplers and to perform some in-situ tests. It was necessary to mobilize the monitoring team when rain was expected or was reported in other locations within the Bay Area. Due to the nature of storms within the Bay Area, and past experience, some "false starts" resulted. The automatic samplers with ISCO flow gages greatly reduced sample losses or poor quality data.

An early warning system was formulated to assist the monitoring team leader in his decision when to mobilize the sampling team or when to place them on standby status. It consisted of:

Early Warning System

1. Forecast Office, National Weather Service, Redwood City (876-9462)
2. Oakland Airport FAA Weather Service (632-8827)
3. Weather Band Radio Broadcast
4. Telephone Weather Service (936-1212)
5. North Bay Contact
6. South Bay Contact

The team leader checked each morning with the weather service and also before leaving work in the afternoon. From these reports the status of the monitoring team was determined.

The monitoring was planned on the basis of obtaining samples from 20 storms each year. The actual number of discrete samples was dependent upon the duration of each storm and rating curve availability.

The normal monitoring time was expected to be between 8 and 10 hours. For the storms still in progress after 10 hours, sampling continued after the sample bottles were replaced. During the second year, 55 gallon stainless steel drums were used instead of sample bottles.

The Alameda County Flood Control District (ACFC&WCD)entered into an agreement with the United States Geological Survey to establish two water quality monitoring stations on Castro Valley Creek. One was located near the intersection of Madison Avenue and Seaview Avenue, and the other near North Third Street and Knox Avenue in Castro Valley. The USGS was responsible for gathering flow and stage data and developing a rating curve for these stations. ACFC&WCD was responsible for collection of samples for chemical parameters and measurement of field parameters The samples were sent to the USGS Laboratory in Denver, Colorado, for analysis.

ACFC&WCD contracted with the USGS to perform the laboratory analysis of the receiving water samples. USGS performs a series of quality control checks on analytical results made by USGS Central Labs. The results were also checked by a person responsible for the project who looks for outliers (values outside the previously observed or expected range of values) and asks the Central Lab to rerun results to confirm their accuracy.

USGS publishes a series of method manuals on the collection and analysis of water samples. These are not repeated here because of their ready availability and wide acceptance.

GAGING STATION SITE SELECTION

Two continuous recording stream gages and two automatic ISCO water samplers with flow meters and printers were installed by USGS and ACFC&WCD on Castro Valley Creek. The Corps of Engineers monitored another station below the confluence of Chabot Creek and Castro Valley Creek.

The criteria used for selecting the sites of the gaging and water quality monitoring stations was as follows:

The watershed had two distinct parts - the urban and non-urban areas. The rural area's conributions of sediments and pollutants were subtracted from the rest of the watershed to give an accurate accounting of pollutant and sediment loading in the urban study area. To accomplish this, a gaging and water quality monitoring station was established on Castro Valley Creek near the intersections of Seaview Avenue and Madison Avenue. This is the boundary line between the urban and rural areas of the watershed. Another gaging and monitoring station was established near the intersection of Knox Street and North Third Street. This station was at the lower end of the watershed and measured the total flow and total pollutant loading of the watershed. With the stations located thus it was possible to separate the contributions of each portion of the watershed. The separation was critical since the study was concerned with the urban area.

PRECIPITATION MONITORING

The objective of the precipitation monitoring task was to provide rainfall data for the project and to develop a precipitation data base which correlated closely with the gaging and water quality monitoring stations.

Storm Definition

Because the stream flow data and water quality data had to be correlated with street surface sampling a "storm" was defined as: a period of time that included a street surface sample taken no more than seven days before a rain event causing runoff and a street surface sample taken as soon as possible (when streets are dry enough) after the termination of rainfall.

Rain Gage Network

Three rain gages were used to monitor precipitation in the project area (Figure A-1). One was located near the intersection of Redwood Road and Proctor Road at Proctor School. This gage measured the rainfall in the upper watershed. Another was located at the Sydney School outside the study area and was used as a check against the Proctor gage. The third one was located at the Castro Valley Fire Station on San Miguel Avenue in central Castro Valley. From these stations, the rainfall record correlated well with the water quality and street surface data collected during the project.

Maintenance

The Proctor and Sydney rain gages were funded by the Corps of Engineers HEC unit and maintained by the U.S. Geological Survey in Menlo Park, California. The Castro Valley Fire Station gage was funded and maintained by the Alameda County Flood Control and Water Conservation District. The stream gaging stations at Knox Street and Seaview Avenue were maintained by the U.S. Geological Survey. The water quality sampling and equipment was maintained by the ACFCWCD.

Stream Flow Measurments

Stream flow measuring was accomplished with the help of the USGS under a cooperative agreement. The agreement provided for gaging stations and equipment with ACFCWCD. The County provided the manpower and equipment to take water quality samples. The USGS supplied laboratory analysis of the water samples.

The stream level was monitored by a manometer-servo water level sensor and recorded on a Stevens digital tape recorder. The water quality samples were taken by a modified ISCO automatic wastewater sampler initiated by a continuous recording ISCO Flowmeter with printer. All of the water quality sampling equipment was powered by a 90 amp hr. 12 volt car battery. Field parameters were measured by an EXTECH pH meter and a YSI conductivity meter with thermometer.

A rating curve was established by the USGS and updated during storm events occurring during the project duration. Both high and low flows were rated.

Water Quality Parameters

Water quality parameters were selected to reflect those that had been monitored in previous water quality investigations and those suggested by EPA. Other parameters were selected to specifically reflect those pollutants most easily identified on street surfaces in the study area. Collected water samples were sent to the USGS Laboratory in Arvada, Colorado for chemical analysis.

The parameters that were monitored are:

Arsenic
Cadmium
Copper
Iron
Lead
Zinc
Mercury
Nickel
Filterable Solids
Nonfilterable Solids
Volatile Suspended Solids
Total Residue

Ammonia Nitrogen
Total Nitrogen
Nitrogen total as Nitrate
Organic Nitrogen
Kjeldahl Nitrogen
Nitrite & Nitrate
Phosphorus
Ortho Phosphate
Cations
Anions
Alkalinity
Sulfate
Hardness

Equipment

An ISCO (Instrumentation Specialties Co.) wastewater sampler connected to an ISCO Flowmeter using a pressure sensitive transducer was used to measure stage and an ISCO Printer was used to record amounts of stormflow and times samples were taken. Some storms were many days in length. The limited capacity of the sampler's sample holder was expanded during the record year by placing the sampler on top of a 55 gal. stainless steel drum. This allowed complete monitoring of even the storms of longest duration.

The power source for the sampling equipment was a 12V 90 amp hour car battery. Each station had 2 batteries assigned to it. During long storms this allowed one to be recharged while the other was in use. One extra battery was kept as a backup for the others. This worked well as one battery did fail during the project.

Sampling Procedure:

The sampling team leader kept track of the weather reports from the National Weather Service each day and determined whether the sampling equipment should be activated. The equipment was activated by a rise in stage. When the sampling equipment was in readiness it used very little power thus could be left on for long periods of time before storms.

The stainless steel container was chilled by the use of 5 gallon containers filled with ice and placed inside the sample container. This kept the sample chilled during monitoring and reduced biological activity that could alter the nutrient samples. When a storm was over and a street surface sample was taken, the water sample was collected and brought back to the ACFCWCD offices to be separated, preserved and shipped to the USGS Water Quality Laboratory for analysis. The prepared samples were packed in ice and shipped in an insulated water tight container by Express Mail. Express Mail provided delivery within 24 hours of sample collection.

Quality Control:

The District used water quality collection and preservation procedures as stated in "Standard Methods for the Examination of Water and Wastewater" Fourteenth Edition, 1975. The laboratory results were checked and monitored by a liaison person at the local USGS Headquarters. Once each year a qualified person from USGS observed the District's personnel sampling procedures and sample preparation techniques. After observation the USGS representative would discuss problems or lapses in procedure he observed. This kept the District personnel keenly aware of the need for strict adherence to procedure that is necessary for a reliable water quality sampling program.

Training:

The District's personnel received training from the USGS on how to sample streams for water quality. This took the form of 1 day of classroom instruction and 1/2 day in the field practicing the procedures learned the day before. The USGS was available for consultation on problems that arose during the sampling program.

Sampling and Calculation Sheets

The attached map, check-off lists, log-in and calculation sheets were used by the field and laboratory personnel. The map (Figures B-1 and B-2) show the approximate locations of the sub-sampling strips and the order for their sampling by test area. The sub-sample check-off sheet (Figure B-3) was used by the sampling team to confirm sampling progress, start and end times (to compare with the times of street cleaner operations during tests), to collect parking density information and to note any unusual conditions. The street cleaner operator sheet (Figure B-4) was used to confirm the start and end times of the street cleaning, to verify that the street cleaner was adjusted properly and to note any unusual cleaning conditions. Figure B-5, the log-in sheet, keeps track of the samples and was very important for quality control. Figures B-6 and B-7 helped the lab personnel make the moisture and particle size calculations and also include many cross-checks for quality control. The original wet tare weight of the sample (measured immediately after returning from sample collection and marked on the sampler check-off list) was checked with the wet tare weight before sample drying. The dry tare weight was also checked with the total dry weight after sieve analysis. If any discrepancies exist, the sample identification was confirmed from the log-in and sampler sheets. Many other values on these sheets were useful for quality assurance (such as percent moisture, sample densities particle size distributions and final curb-mile loading values). The project personnel soon learned reasonable ranges for these data and immediately to suspect problems if the data fell out of the reasonable range. The careful logging and tracking procedures (along with marking all samples) enabled problems to be solved with minimal data loss.

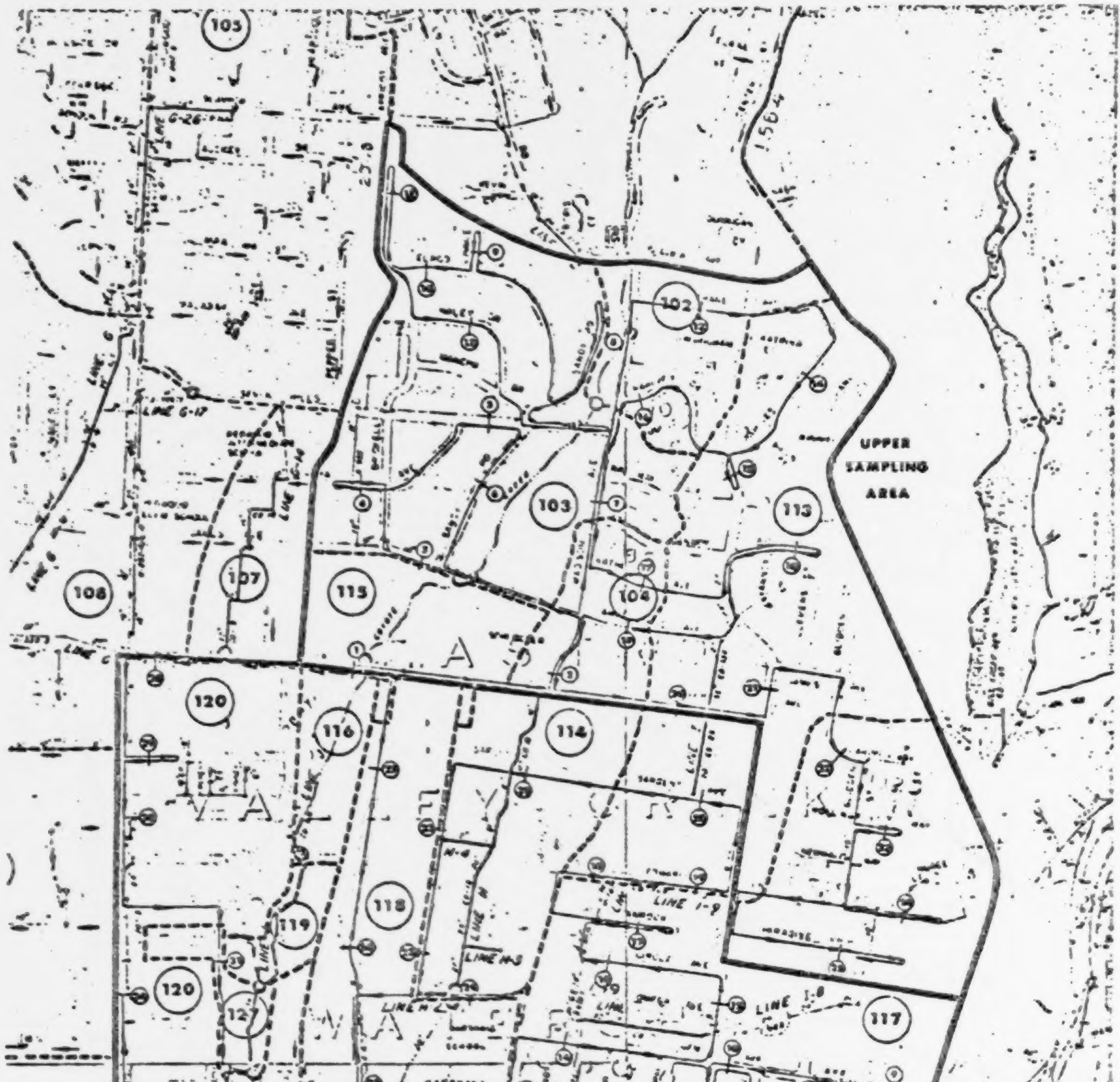
105
102
103
113
104
106
107
115
120
116
114
118
119
120
127
117
128
117
129
130
131
132
UPPER SAMPLING AREA
MIDDLE SAMPLING AREA
1564
LINE G-26
LINE G-17
LINE I-9
LINE H-3
LINE I-8

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FIGURE B-1. TEST AREA MAP - UPPER AND MIDDLE SAMPLING AREAS

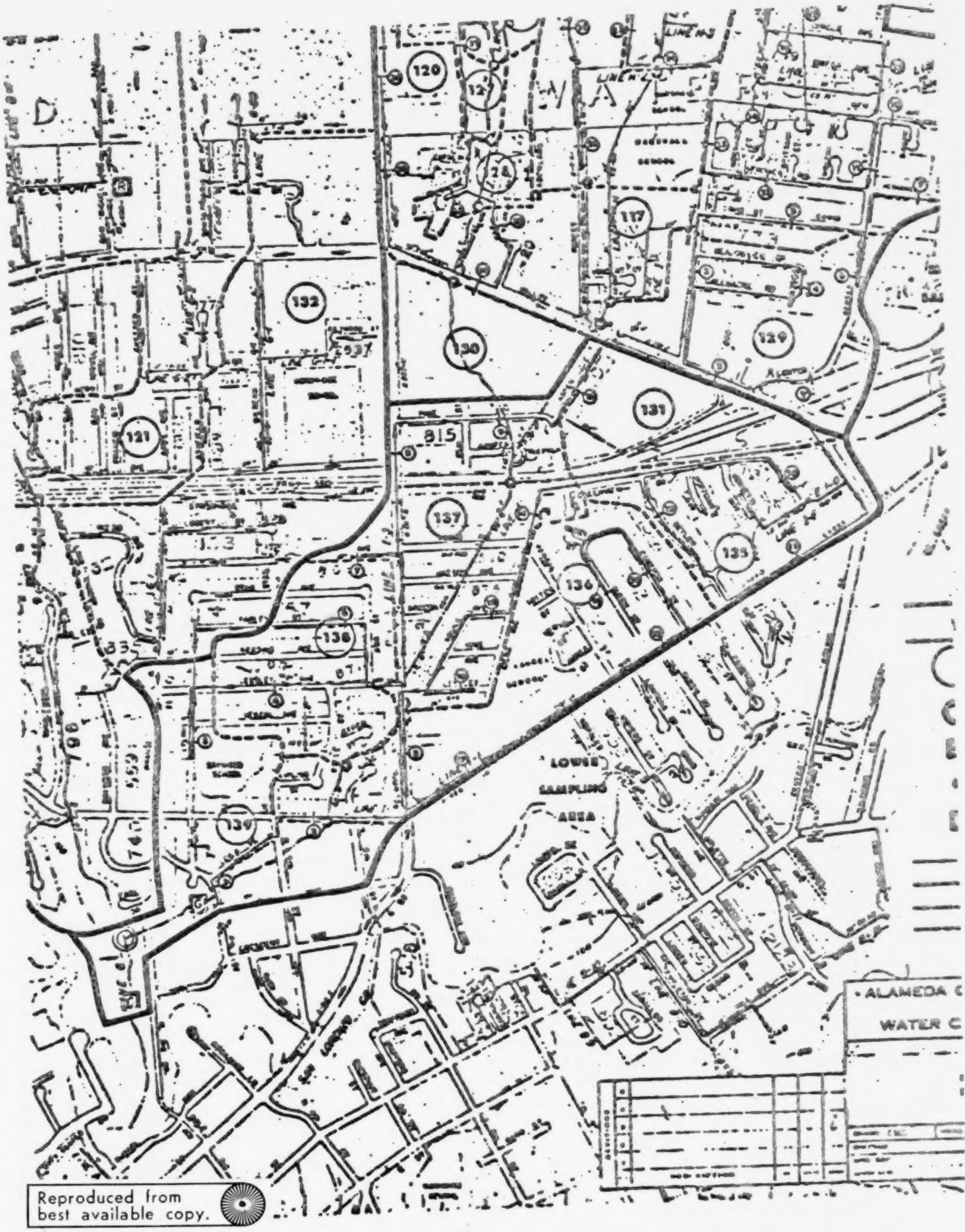
120
127
128
117
129
132
130
131
121
815
137
135
136
138
139
LOWER SAMPLING AREA
ALAMEDA C
WATER C

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FIGURE B-2. TEST AREA MAP - LOWER SAMPLING AREAS

Date ____________________

SIEVE ANALYSIS

SAMPLE #	SIEVE SIZE	TARE WT. (GMS)	GROSS WT. (GMS)	NET WT. (GMS)	PERCENT SAMPLE	LBS/CURB MILE	REMARKS
	1/4"						
	#10						
	#20						
	#30						
	#60						
	#140						
	#325						
	Pan						
	1/4"						
	#10						
	#20						
	#30						
	#60						
	#140						
	#325						
	Pan						
	1/4"						
	#10						
	#20						
	#30						
	#60						
	#140						
	#325						
	Pan						
	1/4"						
	#10						
	#20						
	#30						
	#60						
	#140						
	#325						
	Pan						

FIGURE B-3 PARTICLE SIZE ANALYSIS

Test Area Check List

Date

Sample No. ________________
Time of Start ________________

GWW ________
TARE ________
NWW ________

1
2
3
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51

Time at End ________

Sample No. ________________
Time of Start ________________

GWW ________
TARE ________
NWW ________

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51

Time at End ________

NOTES:

FIGURE B-4 STREET SURFACE SAMPLING CHECK LIST-YEAR TWO

STREET CLEANING TESTS OPERATIONAL INFORMATION

1) Study area: A. Lower Test Area B. Middle Test Area
C. Upper Test Area

2) Date:________________

3) Equipment:____________________

4) Time at start of test:_______________

5) Check list:

a) equipment adjusted to optimum (factory recommended) conditions?

b) hopper empty before test?

6) Estimated volume of hopper contents after test:________________

7) Time at end of test:______________

8) Notes (unusual conditions, rain, etc.):

9) Operator:______________________________

FIGURE B-5. STREET CLEANING TESTS OPERATIONAL INFORMATION

L = Leaf Test
A = Street Accumulation Sample

SAMPLE INVENTORY

Sample ID	Date	Location	Time	Remarks

FIGURE B-6 SAMPLE INVENTORY

SAMPLE WEIGHTS

Sample ID	Pan #	Tare Wt.	Gross Wt. Wet	Net Wt. Wet	Gross Wt Dry	Net Wt. Dry	% Moisture

FIGURE B-7 DRYING CALCULATIONS

Laboratory References for the Chemical Analysis of Street Dirt Samples.

PREPARATION, GRINDING

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DIGESTION

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METALS

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2) Varian Techtron, Analytical Methods for Flame Spectroscopy, 1972
3) "Methods for Cchemical Analysis of Water and Wastes," USEPA, 1974 (EPA-625-16-74-003).
4) "Analytical Methods for Atomic Absorption Spectrophotometry", Perkin-Elmer Corp., 1976.

ORTHO PHOSPHATE & TOTAL PHOSPHATE

1) 1975 Annual Book of ASTM Standards, "Analysis of Coal and Coke Ash", D2795, page 343.
2) "Standard Methods for the Examination of Water and Wastewater", 13th Edition, 1971.
3) "Standard Methods for the Examination of Water and Wastewater", 14th Edition, 1975.
4) "Methods for Chemical Analysis of Water and Wastes", USEPA, Washington, D.C., page 249.

KJELDAHL NITROGEN

1) 1975 Annual Book of ASTM Standards, "Nitrogen in the Analysis of Coal and Coke", D3179-73, page 395-398.
2) "Standard Methods for the Examination of Water and Wastewater", 14th Edition, 1975, APHA, AWWA, WPCF, page 406-440.
3) Instruction Manual, "Ammonia Electrode Model 95-10", 9971, Orion
4) "EPA Maulal of Methods for Chemical Analysis of Water and Wastes", (EPA 625-16-74-03), page 168-171.
5) "Automating Manual Methods using Technicon Auto Analyzer II Systems Techniques", Technicon, 1972.

VOLATILE SOLIDS

1) 1975 Annual Book of ASTM Standards, "Volatile Matter in the Analysis Sample of Coal and Coke", D3175-73 (modified procedure), page 375-377.

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SULFUR

1) "Standard Methods for the Examination of Water and Wastewater", 14th Edition, 1975.

2) "Sulfate in Water and Wastewater", Technicon Auto Analyzer II Industrial Method No. 118-71W/B, Revised: 1977, Released: 1972, Technicon Industrial Systems.

3) Fisher Model 470 Sulfur Analyzer Instruction Manual, pages 34-35.

C.O.D.

1) USDA Handbook #60, page 105.

2) Jackson, M.L. "Soil Chemical Analysis", Prentice Hall, Englewood Cliffs, NJ, 1958.

ARSENIC

1) "Determination of Selenium in Water, Wastewater, Sediments, and Sludge by Flameless Atomic Absorption Spectroscopy", Martin and Kopp, AA Newsletter, No. 5, 1975.

2) "Atomic Absorption Analysis with the Graphite Furnace using Matrix Modification", Ediger, AA Newsletter, V. 14 No. 5, 1975.

3) Federal Register, Part II, EPA Water Programs, "Guidelines Establishing Test Procedures for the Analysis of Pollutants", December 1, 1976.

4) "Analytical Methods for Atomic Absorption Spectropnotometry using the HGA Graphite Furnace", Perkin-Elmer, 1973.

5) "Methods for Chemical Analysis of Water and Waster", USEPA EPA 600/4-79-020, March, 1979.

APPENDIX C. STREET DIRT DEPOSITION AND ACCUMULATION RATES

TABLE C-1. CASTRO VALLEY STREET DIRT MEDIAN PARTICLE SIZE CHANGES FOR VARIOUS ACCUMULATION PERIODS

Days After Street Cleaning or Significant Rain	First Yr. Lower Area Value (1)	First Yr. Lower Area % Change Per Day	First Yr. Middle Area Value (1)	First Yr. Middle Area % Change Per Day	First Yr. Upper Area Value (1)	First Yr. Upper Area % Change Per Day	Second Yr. Complete Area Value (1)	Second Yr. Complete Area % Change Per Day
0	380u	-	560u	-	430u	-	490u	-
1	390	2.6	565	0.9	440	2.3	490	0.3
3	400	2.0	570	0.6	460	2.3	490	0.3
5	420	2.0	575	0.4	490	2.0	495	0.3
7	440	1.5	580	0.4	500	1.5	500	0.3
10	450	1.5	590	0.3	520	1.3	500	0.3
20	510	1.3	610	0.3	570	1.0	510	0.2
30	530	0.4	615	0.1	590	0.4	530	0.2
55	550	0.2	620	0.1	610	0.1	560	0.1
75	-	-	-	-	-	-	590	0.1
110	-	-	-	-	-	-	600	0.1

(1) Values are expressed in microns.

TABLE C-2. CASTRO VALLEY LOADING, DEPOSITION AND ACCUMULATION VALUES

LEAD

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.9	-	1.0	-	0.35	-	0.5	-
1	1.0	0.06	1.1	0.05	0.35	0.025	0.6	0.06
3	1.1	0.05	1.2	0.05	0.40	0.020	0.7	0.05
5	1.2	0.04	1.3	0.05	0.45	0.020	0.8	0.05
7	1.2	0.03	1.4	0.04	0.55	0.020	0.9	0.05
10	1.3	0.03	1.5	0.04	0.60	0.015	1.0	0.04
20	1.4	0.02	1.9	0.03	0.70	0.010	1.3	0.03
30	1.5	0.01	2.2	0.03	0.75	0.010	1.5	0.02
55	1.6	0.005	2.8	0.02	0.90	<0.010	1.8	0.01
75	-	-	-	-	-	-	1.9	0.01
110	-	-	-	-	-	-	2.0	<0.01

ARSENIC

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	.009	-	.008	-	.004	-	.006	-
1	.010	.0006	.008	.0005	.009	.0004	.007	.0007
3	.011	.0005	.010	.0005	.005	.0004	.008	.0006
5	.012	.0005	.011	.0005	.006	.0004	.010	.0006
7	.013	.0004	.012	.0005	.007	.0003	.010	.0005
10	.014	.0004	.013	.0005	.008	.0003	.013	.0004
20	.017	.0003	.017	.0004	.011	.0003	.017	.0003
30	.020	.0002	.021	.0003	.013	.0002	.020	.0002
55	.022	.0001	.026	.0002	.015	.0001	.025	.0001
75	-	-	-	-	-	-	.026	<.0001
110	-	-	-	-	-	-	.026	<.0001

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile/day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

TABLE C-3. CASTRO VALLEY LOADING, DEPOSITION AND ACCUMULATION VALUES

CHROMIUM

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldq. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.017	0	0.14	-	0.06	-	0.026	-
1	0.18	0.003	0.15	0.005	0.06	0.003	0.030	0.005
3	0.19	0.003	0.16	0.005	0.07	0.002	0.050	0.005
5	0.19	0.003	0.17	0.004	0.07	0.002	0.055	0.005
7	0.19	0.002	0.18	0.004	0.08	0.002	0.060	0.004
10	0.20	0.002	0.20	0.004	0.08	0.002	0.075	0.003
20	-	-	0.24	0.003	0.10	0.002	0.10	0.002
30	-	-	0.26	0.002	0.11	0.001	0.12	0.002
55	-	-	0.30	0.001	0.12	<0.001	0.13	0.001
75	-	-	-	-	-	-	0.14	0.001
110	-	-	-	-	-	-	0.15	<0.001

COPPER

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.040	-	0.035	-	0.020	-	0.023	-
1	0.045	0.0015	0.035	0.002	0.021	0.001	0.025	0.003
3	0.050	0.0015	0.045	0.002	0.023	0.0008	0.030	0.003
5	0.055	0.001	0.050	0.002	0.024	0.0007	0.036	0.002
7	0.060	0.001	0.055	0.0015	0.026	0.0007	0.040	0.002
10	0.060	0.001	0.060	0.0015	0.029	0.0006	0.050	0.002
20	0.060	0.0005	0.070	0.0015	0.035	0.0006	0.062	0.001
30	0.065	0.0005	0.085	0.001	0.040	0.0004	0.066	0.0004
55	0.065	<0.0005	0.090	<0.001	0.045	0.0002	0.069	<0.0001
75	-	-	-	-	-	-	0.070	<0.0001
110	-	-	-	-	-	-	0.070	<0.0001

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile/day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

TABLE C-4. CASTRO VALLEY LOADING, DEPOSITION AND ACCUMULATION VALUES

VOLATILE SOLIDS

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	50	-	50	-	24	-	25	-
1	50	3	50	3	25	2	30	5
3	60	3	60	3	30	2	40	4
5	65	2	65	3	32	2	50	4
7	65	2	70	2	37	1	60	3
10	75	2	75	2	40	1	70	3
20	90	2	100	2	52	1	85	2
30	110	2	115	2	60	1	100	1
55	120	1	135	1	72	<1	120	1
75	-	-	-	-	-	-	130	1
110	-	-	-	-	-	-	150	1

COD

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	40	-	30	-	20	-	20	-
1	40	3	30	4	20	2	23	3
3	50	3	40	4	25	2	28	3
5	55	3	50	4	30	2	34	3
7	60	3	55	3	35	2	39	2
10	65	2	65	3	40	1	48	2
20	80	2	95	3	50	1	60	1
30	90	1	120	2	55	<1	70	1
55	100	<1	150	1	60	<1	88	1
75	-	-	-	-	-	-	100	<1
110	-	-	-	-	-	-	110	<1

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

TABLE C-5. CASTRO VALLEY LOADING, DEPOSITION AND ACCUMULATION VALUES

ORTHO PHOSPHATE

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.025	-	0.024	-	0.012	-	0.006	-
1	0.025	0.002	0.025	0.001	0.012	0.0005	0.007	0.0007
3	0.026	-	0.027	0.001	0.013	0.0004	0.008	0.0007
5	0.027	-	0.029	0.001	0.014	0.0004	0.010	0.0006
7	0.028	-	0.030	0.0008	0.015	0.0004	0.011	0.0006
10	0.028	-	0.033	0.0007	0.016	0.0003	0.014	0.0005
20	0.029	-	0.038	0.0006	0.019	0.0002	0.017	0.0004
30	-	-	0.042	0.0004	0.021	0.0001	0.020	0.0002
55	-	-	0.048	0.0002	0.023	<0.0001	0.024	0.0002
75	-	-	-	-	-	-	0.026	0.0001
110	-	-	-	-	-	-	0.028	<0.0001

PHOSPHORUS

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.27	-	0.26	-	0.15	-	0.15	-
1	0.29	0.017	0.29	0.013	0.15	0.005	0.18	0.013
3	0.32	0.014	0.32	0.012	0.17	0.005	0.21	0.013
5	0.35	0.013	0.35	0.012	0.18	0.005	0.23	0.012
7	0.37	0.010	0.36	0.012	0.19	0.005	0.25	0.010
10	0.40	0.009	0.41	0.012	0.20	0.004	0.29	0.010
20	0.46	0.007	0.50	0.010	0.25	0.003	0.37	0.007
30	0.50	0.005	0.58	0.008	0.28	0.002	0.41	0.004
55	0.54	0.001	0.72	0.003	0.33	0.001	0.49	0.002
75	-	-	-	-	-	-	0.54	0.002
110	-	-	-	-	-	-	0.60	0.001

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile/day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

TABLE C-6. CASTRO VALLEY LOADING, DEPOSITION AND ACCUMULATION VALUES

SULPHUR

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.6	-	0.5	-	0.30	-	0.35	-
1	0.7	0.04	0.6	0.03	0.30	0.02	0.40	0.03
3	0.8	0.04	0.7	0.03	0.30	0.02	0.50	0.03
5	0.8	0.03	0.7	0.03	0.40	0.02	0.60	0.03
7	0.8	0.03	0.8	0.03	0.40	0.02	0.65	0.03
10	0.9	0.03	0.8	0.03	0.50	0.02	0.75	0.03
20	1.3	0.02	1.1	0.02	0.60	0.01	0.90	0.02
30	1.4	0.02	1.3	0.02	0.75	0.01	1.10	0.02
55	1.5	0.01	1.6	0.01	0.90	0.01	1.20	0.01
75	-	-	-	-	-	-	1.30	<0.01
110	-	-	-	-	-	-	1.40	<0.01

ZINC

Days After Street Cleaning or Significant Rain	First Yr. Lower Area		First Yr. Middle Area		First Yr. Upper Area		Second Yr. Complete Area	
	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)	Ldg. Value (1)	Accum. Rate (2)
0	0.19	-	0.14	-	0.06	-	0.08	-
1	0.20	0.006	0.15	0.008	0.07	0.004	0.08	0.007
3	0.21	0.005	0.17	0.007	0.08	0.004	0.09	0.007
5	0.22	0.004	0.18	0.006	0.08	0.004	0.12	0.007
7	0.22	0.004	0.18	0.005	0.09	0.003	0.13	0.006
10	0.23	0.003	0.21	0.005	0.11	0.003	0.15	0.006
20	0.25	0.002	0.27	0.005	0.13	0.003	0.18	0.004
30	0.26	0.001	0.31	0.004	0.14	0.002	0.20	0.003
55	0.26	<0.001	0.37	0.002	0.16	<0.001	0.24	0.002
75	-	-	-	-	-	-	0.27	0.001
110	-	-	-	-	-	-	0.28	<0.001

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile/day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

Castro Valley Loading, Deposition and Accumulation Valves for Total Kjeldahl Nitrogen

Days After Street Cleaning or Significant Rain	First Yr. Lower Area Ldg. Value (1)	First Yr. Lower Area Accum. Rate (2)	First Yr. Middle Area Ldg. Value (1)	First Yr. Middle Area Accum. Rate (2)	First Yr. Upper Area Ldg. Value (1)	First Yr. Upper Area Accum. Rate (2)	Second Yr. Complete Area Ldg. Value (1)	Second Yr. Complete Area Accum. Rate (2)
0		-		-		-	0.5	-
1							0.6	0.04
3							0.7	0.04
5							0.8	0.03
7							0.8	0.03
10							0.9	0.03
20							1.2	0.03
30							1.4	0.02
55							1.7	0.01
75	-	-	-	-	-	-	1.8	0.01
110	-	-	-	-	-	-	2.0	<0.01

(1) Loading (Ldg.) value units are lbs/curb-mile.

(2) Accumulation rate units are lbs/curb-mile/day, for the time period from the preceeding time to the time shown. As an example, the value shown for 20 days is the average accumulation rate for the time period 10 to 20 days after cleaning or significant rain. In addition, the first accumulation rate shown (for the 0 to 1 day period) is estimated to be the deposition rate.

APPENDIX D. POSSIBLE URBAN RUNOFF IMPROVEMENTS RESULTING FROM STREET CLEANING

TABLE D-1. STORM HISTORY AND IT'S EFFECTS ON THE STREET CLEANING PROGRAM - YEAR ONE

Monitored Storm Code	Storm Period Date	Storm Period Duration (days)	Total Rain (in.)	Urban Runoff (acre-feet)	Preceeding Dry Period for Street Cleaning (days)	Max. Cleaning Effort Possible (Passes Per Preceeding Week
	11/12-13/78	NA	0.27	1.2	Very long	3
	11/19-22	NA	1.96	28.9	6	3
	12/1	NA	0.36	5.3	9	3
A	12/17-18*	12.5	0.44	5.1	16	3
	1/3-5/79	1.3	0.14	0.9	16	3
B, C & D	1/7-11*	3.5	4.34	151.6	3	2
E	1/14-15*	1.5	1.71	66.6	3	2
	1/17	0.2	0.24	5.9	2	1
	1/30	0.01	0.01	0	13	3
	2/3	0.01	0.01	0	17	3
F,G,H,I, J & K	2/13-3/1*	15	4.94	157.9	27	3
	3/3	4.5	0.03	0	3	2
L	3/15-17*	2.1	0.75	9.5	15	3
M	3/26-28*	2.3	1.98	35.0	9	3
	4/6	0.01	0.02	0	9	3
	4/9	0.01	0.01	0	12	3
	4/16-17	0.6	0.09	1.0	19	3
	4/22-23	0.9	0.15	0.7	5	3
N	4/25-26*	0.5	0.38	6.8	2	1
	5/5-8	2.3	0.14	1.9	9	3
	5/15	0.01	0.01	0	16	3
TOTAL YEAR 1		47.3+ days	17.98	478		56

TABLE D-2. STORM HISTORY AND ITS EFFECTS ON THE STREET CLEANING PROGRAM - YEAR TWO

Monitored Storm Code	Storm Period Date	Storm Period Duration (days)	Total Rain (in.)	Urban Runoff (acre-feet)	Preceeding Dry Period for Street Cleaning (days)	Max. Cleaning Effort Possible (Passes Per Preceeding Week)
	10/15/79	0.01	0.01	0	169	3
1	10/18-20*	1.1	1.01	19.8	172	3
	10/25-26	1.2	1.69	52.3	5	3
	10/30-31	0.1	0.04	0	4	2
3	11/2-5*	0.6	0.60	33.0	9	3
	11/7-8	0.6	0.05	0	2	1
4	11/16-17*	0.5	0.83	17.1	10	3
5	11/22-25*	3.4	0.73	23.7	5	3
6	12/19-20*	1.4	0.57	7.4	24	3
7	12/23-25*	2.7	3.52	140.4	3	2
8	12/30-31*	1.5	0.62	23.6	5	3
	1/1/80	0.01	0.01	0	1	1
	1/2	0.01	0.01	0	2	1
	1/4	0.01	0.01	0	4	2
9	1/8-17*	8.7	4.12	110.5	7	3
10	2/14-21*	10.8	5.93	343.1	28	3
	2/24	0.01	0.01	0	3	2
11	2/27*	0.4	0.73	22.5	6	3
	2/28	0.01	0.01	0	1	1
	2/29	0.01	0.01	0	2	1
12 & 13	3/2-6*	3.2	1.27	42.5	3	2
	3/11	0.01	0.01	0	5	3
	3/14	0.1	0.03	0	8	3
	3/15	0.01	0.01	0	9	3
	3/21	0.01	0.01	0	15	3
14	3/25*	0.2	0.19	2.0	19	3
	3/27	0.01	0.01	0	2	1
15	4/4-5*	NA	1.06	28.9	10	3
16 & 17	4/20-22*	NA	0.39	10.4	15	3
TOTAL YEAR 2		36.6+ Days	23.49	877		70

TABLE D-3.STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

STORM CODE:	C	D & E	F	G & H & I & J	K	L	M	N	1	3
TOTAL SOLIDS:										
Before storm street (lbs)	66,300	15,400	37,200	27,100	29,200	43,800	45,000	33,500	32,500	27,900
After storm street (lbs)	16,400	18,800	23,000	18,500	37,600	22,300	23,300	23,900	21,100	8,800
△ street (lbs)	49,900	-3,400	14,200	8,640	-8,400	21,600	21,700	9,500	11,400	19,100
Run-off yield (lbs)	112,000	65,600	8,000	119,000	12,300	6,990	26,500	4,970	26,500	51,500
Before/after ratio	4.0	0.82	1.6	1.5	0.78	2.0	1.9	1.4	1.5	3.2
Before/yield ratio	0.59	0.23	4.7	0.23	2.4	6.3	1.7	6.7	1.2	0.54
△ street/yield ratio	0.45	-0.05	1.8	0.073	-0.68	3.1	0.82	1.9	0.43	0.37
LEAD:										
Before storm street (lbs)	245	33	63	39	50	69	65	47	73	57
After storm street (lbs)	24	27	32	28	64	27	34	33	44	5.2
△ street (lbs)	221	7	30	11	-14	42	31	14	29	52
Run-off yield (lbs)	-	-	19	80	9.6	6.7	21	8.2	179	104
Before/after ratio	10	1.2	2.0	1.4	0.78	2.6	1.9	1.4	1.7	11
Before/yield ratio	-	-	3.3	0.49	5.2	10	3.1	5.7	0.41	0.55
△ street/yield ratio	-	-	1.6	0.14	-1.5	6.2	1.5	1.7	0.16	0.50
ZINC:										
Before storm street (lbs)	33	4.9	9.8	7.0	8.1	12	12	8.5	9.6	7.7
After storm street (lbs)	3.6	5.1	5.7	4.7	12	4.9	5.9	6.0	6.0	0.62
△ street (lbs)	30	-0.2	4.1	2.3	-3.5	6.9	5.7	2.5	3.6	7.1
Run-off yield (lbs)	70	41	9.6	54	9.9	4.5	14	4.1	119	77
Before/after ratio	9.2	0.96	1.7	1.5	0.68	2.4	2.0	1.4	1.6	12
Before/yield ratio	0.47	0.12	1.0	0.13	0.82	2.7	0.86	2.1	0.08	0.1
△ street/yield ratio	0.42	-0.005	0.43	0.043	-0.4	1.5	0.41	0.61	0.03	0.09
COD:										
Before storm street (lbs)	10,600	1,750	3,070	2,160	2,370	3,740	3,930	2,850	4,880	4,080
After storm street (lbs)	1,310	1,500	1,830	1,440	2,980	1,790	1,860	1,880	3,280	490
△ street (lbs)	9,330	257	1,240	720	-600	1,950	2,070	970	1,660	3,590
Run-off yield (lbs)	20,000	-	7,200	22,600	3,710	2,490	7,400	2,020	12,400	16,700
Before/after ratio	8.1	1.2	1.7	1.5	0.80	2.1	2.1	1.5	1.5	8.6
Before/yield ratio	1.1	-	0.43	0.10	0.63	1.5	0.53	1.4	0.39	0.24
△ street/yield ratio	0.47	-	0.17	0.032	-0.2	0.78	0.28	0.48	0.13	0.21

△ street - before storm street loading minus the after storm street loading

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

	STORM CODE:								
	4	5	6	7	8	9	10	11	12 & 13
TOTAL SOLIDS:									
Before storm street (lbs)	13,200	15,000	32,900	21,400	21,400	30,700	16,300	17,700	13,500
After storm street (lbs)	10,800	7,000	16,700	14,600	20,500	17,400	11,600	6,620	15,300
△ street (lbs)	2,400	8,000	16,200	6,800	900	13,300	4,700	11,100	-1,800
Run-off yield (lbs)	6,890	9,090	4,710	48,100	14,400	128,000	217,000	33,700	44,500
Before/after ratio	1.2	2.1	2.0	1.5	1.0	1.8	1.4	2.7	0.88
Before/yield ratio	1.9	1.7	7.0	0.44	1.5	0.23	0.08	0.52	0.30
△ street/yield ratio	0.35	0.88	3.4	0.14	0.06	0.12	0.02	0.32	-0.04
LEAD:									
Before storm street (lbs)	23	25	47	26	29	42	25	26	21
After storm street (lbs)	17	11	19	18	21	19	14	8	22
△ street (lbs)	6	14	28	9	8	23	11	18	-1
Run-off yield (lbs)	29	29	22	38	32	36	286	18	28
Before/after ratio	1.3	2.3	2.5	1.5	1.4	2.2	1.8	3.2	1
Before/yield ratio	0.78	0.86	2.1	0.69	0.9	1.2	0.09	1.4	0.74
△ street/yield ratio	0.19	0.49	1.3	0.23	0.24	0.65	0.04	1.0	-0.04
ZINC:									
Before storm street (lbs)	3.3	3.4	7.0	3.7	4.1	5.8	3.6	3.7	2.9
After storm street (lbs)	2.6	1.5	2.7	2.6	3.3	2.8	2.1	1.2	3.1
△ street (lbs)	0.7	1.9	4.3	1.1	0.8	3.0	1.5	2.5	-0.2
Run-off yield (lbs)	12	16	13	51	20	31	163	16	21
Before/after ratio	1.3	2.3	2.6	1.4	1.2	2.1	1.7	3.1	0.9
Before/yield ratio	0.27	0.21	0.55	0.07	0.21	0.19	0.02	0.23	0.14
△ street/yield ratio	0.06	0.12	0.34	0.02	0.04	0.10	0.01	0.15	-0.01
COD:									
Before storm street (lbs)	1,190	1,450	3,130	2,060	2,170	2,900	1,240	1,400	1,120
After storm street (lbs)	950	670	1,450	1,270	1,400	1,600	980	440	1,140
△ street (lbs)	240	780	1,680	790	770	1,300	260	960	-20
Run-off yield (lbs)	5,020	4,220	-	15,700	4,090	19,300	50,400	7,300	10,950
Before/after ratio	1.3	2.1	2.1	1.6	1.6	1.8	1.3	32	0.98
Before/yield ratio	0.24	0.34	-	0.13	0.53	0.15	0.02	0.19	0.10
△ street/yield ratio	0.05	0.18	-	0.05	0.19	0.07	0.01	0.13	-0.002

△ street - before storm street loading minus the after storm street loading.

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

	STORM CODE:						
	14	15	16 & 17	Min.	Max	Avg.	Avg. lb/curb-Mile
TOTAL SOLIDS:							
Before storm street (lbs)	24,200	30,300	43,600	13,200	66,300	29,000	560
After storm street (lbs)	16,500	25,300	26,600	6,620	37,600	18,300	350
△ street (lbs)	7,700	5,000	17,000	-8,400	49,900	10,700	210
Run-off yield (lbs)	688	10,100	11,500	688	217,000	43,700	850
Before/after ratio	1.5	1.2	1.6	0.78	4.0	1.7	-
Before/yield ratio	35	3.0	3.8	0.08	7.0	3.6	-
△ street/yield ratio	11	0.50	1.5	-0.68	11	1.2	-
LEAD:							
Before storm street (lbs)	40	43	70	21	245	53	1.0
After storm street (lbs)	25	35	34	5.2	64	26	0.50
△ street (lbs)	15	8	36	-14	221	27	0.52
Run-off yield (lbs)	1.8	14	15	1.8	179	49	0.95
Before/after ratio	1.6	1.2	2.1	0.78	11	2.5	-
Before/yield ratio	2.7	3.2	4.7	0.09	5.7	2.4	-
△ street/yield ratio	82	0.6	2.4	-1.5	3.2	1.3	-
ZINC:							
Before storm street (lbs)	5.6	6.2	11.1	2.9	33	7.9	0.15
After storm street (lbs)	3.5	5.0	4.8	0.62	12	4.1	0.08
△ street (lbs)	2.1	12	6.3	-3.5	30	3.8	0.07
Run-off yield (lbs)	1.3	22	9.3	1.3	163	35	0.68
Before/after ratio	1.6	1.2	2.3	0.68	9.2	2.5	-
Before/yield ratio	4.4	0.29	1.2	0.02	4.4	0.7	-
△ street/yield ratio	1.7	0.06	0.68	-0.4	1.7	0.3	-
COD:							
Before storm street (lbs)	2,070	2,520	3,620	1,120	10,600	2,900	56
After storm street (lbs)	1,200	1,630	2,170	490	3,280	1,470	28
△ street (lbs)	870	890	1,450	-600	9,330	1,430	28
Run-off yield (lbs)	-	7,590	-	2,020	50,400	12,200	240
Before/after ratio	1.7	1.6	1.7	0.80	8.6	2.3	-
Before/yield ratio	-	0.33	-	0.02	1.5	0.5	-
△ street/yield ratio	-	0.12	-	-0.2	0.78	0.2	-

△ street - before storm street loading minus the after storm street loading .

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS (Concluded)

STORM CODE:	C	D & E	F	G & H & I & J	K	L	M	N	1	3
CHROMIUM:										
Before storm street (lbs)	30	4.9	8.7	6.2	6.9	12	13	9.5	4.9	4.2
After storm street (lbs)	4	4.2	5.3	4.1	8.7	5.7	7	6.8	3.3	0.5
△ street (lbs)	26	0.7	3.4	2.1	-1.8	6.6	6	2.7	1.6	3.7
Run-off yield (lbs)	-	-	0.55	5.7	0.86	0.63	1.9	0.25	3.3	0.1
Before/after ratio	8.1	1.2	1.6	1.5	0.8	2.1	2.0	1.4	1.5	8.1
Before/yield ratio	-	-	16	1.1	8.0	19	6.8	38	1.5	42
△ street/yield ratio	-	-	6.2	0.37	-2.1	11	3.3	11	0.5	37
SULFUR:										
Before storm street (lbs)	140	22	43	29	33	35	36	27	45	38
After storm street (lbs)	16	20	25	19	42	16	18	19	30	6.2
△ street (lbs)	120	2	18	10	-8	19	18	8	15	32
Run-off yield (lbs)	-	-	-	-	-	-	-	-	-	-
Before/after ratio	8.8	1.1	1.7	1.5	0.8	2.2	2.0	1.4	1.5	6.1
Before/yield ratio	-	-	-	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-	-	-	-
VOLATILE SOLIDS:										
Before storm street (lbs)	1,200	2,100	1,900	1,300	1,500	3,100	3,200	2,800	3,410	2,940
After storm street (lbs)	1,600	900	1,100	880	1,800	1,500	1,400	1,700	2,510	360
△ street (lbs)	400	1,200	800	460	-300	1,600	1,800	1,100	900	2,580
Run-off yield (lbs)	-	-	-	-	-	-	-	-	-	-
Before/after ratio	7.5	2.3	1.7	1.5	0.8	2.1	2.3	1.6	1.4	8.1
Before/yield ratio	-	-	-	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-	-	-	-
TOTAL KJELDAHL N:										
Before storm street (lbs)	77	12	23	16	18	17	18	13	63	51
After storm street (lbs)	9	11	13	10	22	8	8	9	45	11
△ street (lbs)	68	1	10	6	-4	9	10	4	18	40
Run-off yield (lbs)	470	-	83	470	97	18	135	41	406	293
Before/after ratio	8.6	1.1	1.8	1.6	0.8	2.1	2.2	1.5	1.4	4.6
Before/yield ratio	0.16	-	0.23	0.03	0.19	0.94	0.13	0.30	0.15	0.17
△ street/yield ratio	0.15	-	0.12	0.01	-0.04	0.48	0.07	0.10	0.04	0.14

△ street - before storm street loading minus the after storm street loading.

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

STORM CODE:	4	5	6	7	8	9	10	11	12 & 13
CHROMIUM:									
Before storm street (lbs)	1.3	1.6	4.7	3.2	3.3	4.4	2.2	2.4	1.9
After storm street (lbs)	1.0	0.7	2.5	2.1	2.9	2.6	1.8	1.0	1.9
△ street (lbs)	0.3	0.9	2.2	1.1	0.4	1.8	0.4	1.4	0.01
Run-off yield (lbs)		0.07	-	2.5	2.7	-	1.2		0.3
Before/after ratio	1.3	2.2	1.9	1.5	1.1	1.7	1.2	2.5	1.0
Before/yield ratio	-	25	-	1.3	1.2	-	1.8	-	6.3
△ street/yield ratio	-	13	-	0.44	0.15	-	0.37	-	0.04
SULFUR:									
Before storm street (lbs)	18	19	39	22	22	34	19	20	16
After storm street (lbs)	15	9	18	16	22	17	13	8	18
△ street (lbs)	3	10	21	6	0.1	16	7	13	-2.3
Run-off yield (lbs)	-	-	-	-	-	-	-	-	-
Before/after ratio	1.2	2.1	2.2	1.4	1.0	2.0	1.5	2.7	0.86
Before/yield ratio	-	-	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-	-	-
VOLATILE SOLIDS:									
Before storm street (lbs)	980	1,090	2,590	1,760	1,810	2,410	1,100	1,190	990
After storm street (lbs)	740	520	1,340	1,160	1,460	1,390	840	440	1,000
△ street (lbs)	240	570	1,250	600	350	1,010	260	750	-10
Run-off yield (lbs)	-	-	-	-	-	-	-	-	-
Before/after ratio	1.3	2.1	1.9	1.5	1.2	1.7	1.3	2.7	0.90
Before/yield ratio	-	-	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-	-	-
TOTAL KJELDAHL N:									
Before storm street (lbs)	21	21	53	32	30	45	24	25	27
After storm street (lbs)	18	10	26	23	32	27	18	10	22
△ street (lbs)	3	11	27	8	-2	18	6	14	5
Run-off yield (lbs)	61	78	-	-	120	530	1,390	156	-
Before/after ratio	1.2	2.2	2.0	1.4	0.94	1.7	1.3	2.5	1.2
Before/yield ratio	0.34	0.28	-	-	0.26	0.09	0.02	0.16	-
△ street/yield ratio	0.06	0.15	-	-	-0.02	0.03	0.004	0.09	-

△ street - before storm street loading minus the after storm street loading.

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

	STORM CODE: 14	15	16 & 17	Min.	Max.	Avg.	Avg. lb/curb-Mile
CHROMIUM:							
Before storm street (lbs)	3.3	4.2	5.8	1.3	30	6.3	0.12
After storm street (lbs)	2.3	3.5	3.8	0.5	8.7	3.4	0.066
△ street (lbs)	1.0	0.7	2.0	-1.8	26	2.9	0.056
Run-off yield (lbs)	-	-	-		5.7	1.3	0.025
Before/after ratio	1.4	1.2	1.5	0.8	8.1	2.1	-
Before/yield ratio	-	-	-	1.1	42	13	-
△ street/yield ratio	-	-	-	-2.1	37	6.3	-
SULFUR:							
Before storm street (lbs)	52	35	53	16	140	36	0.70
After storm street (lbs)	20	29	28	8	42	19	0.37
△ street (lbs)	32	6	25	-8	120	17	0.33
Run-off yield (lbs)	-	-	-	-	-	-	-
Before/after ratio	2.6	1.2	1.9	0.8	8.8	2.2	-
Before/yield ratio	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-
VOLATILE SOLIDS:							
Before storm street (lbs)	1,600	2,210	2,790	980	3,410	2,000	39
After storm street (lbs)	1,140	1,540	1,910	360	2,510	1,240	24
△ street (lbs)	460	670	880	-300	2,580	760	15
Run-off yield (lbs)	-	-	-	-	-	-	-
Before/after ratio	1.4	1.4	1.5	0.8	8.1	2.2	-
Before/yield ratio	-	-	-	-	-	-	-
△ street/yield ratio	-	-	-	-	-	-	-
TOTAL KJELDAHL N:							
Before storm street (lbs)	36	46	67	12	77	33	0.64
After storm street (lbs)	26	38	40	8	45	20	0.39
△ street (lbs)	10	8	27	-4	68	13	0.25
Run-off yield (lbs)	-	-	-	18	1,390	290	5.6
Before/after ratio	1.4	1.2	1.7	0.8	8.6	2.0	-
Before/yield ratio	-	-	-	0.02	0.94	0.2	-
△ street/yield ratio	-	-	-	-0.04	0.48	0.1	-

△ street - before storm street loading minus the after storm street loading

TABLE D-3 STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS (Contd.)

	STORM CODE: C	D & E	F	G & H & I & J	K	L	M	N	1	3
TOTAL P:										
Before storm street (lbs)	66	11	19	13	15	18	18	14	19	16
After storm street (lbs)	8	9	11	9	18	8.2	9.1	9.6	13	4.1
△ street (lbs)	58	2	8	4	-3	9.3	9.2	4.1	5.4	12
Run-off yield (lbs)	130	-	23	130	13	6.7	38	5.8	44	58
Before/after ratio	8.3	1.2	1.7	1.4	0.83	2.2	1.1	1.5	1.4	3.9
Before/yield ratio	0.51	-	0.82	0.10	1.2	2.7	0.47	2.4	0.43	0.27
△ street/yield ratio	0.45	-	0.35	0.031	-0.23	1.4	0.24	0.71	0.12	0.21
O-PO4:										
Before storm street (lbs)	5.1	0.85	1.4	1.0	1.2	1.9	2.0	1.6	0.9	0.8
After storm street (lbs)	0.6	0.71	0.88	0.7	1.4	0.91	1.0	1.1	0.6	0.2
△ street (lbs)	4.5	0.14	0.55	0.3	-0.2	0.94	1.0	0.46	0.3	0.6
Run-off yield (lbs)	-	-	29	260	8.9	2.9	15	0.9	35	29
Before/after ratio	8.5	1.2	1.6	1.4	0.86	2.1	2.0	1.5	1.5	4.6
Before/yield ratio	-	-	0.05	0.004	0.14	0.66	0.13	1.7	0.03	0.03
△ street/yield ratio	-	-	0.02	0.001	-0.004	0.32	0.07	0.49	0.01	0.02
ARSENIC:										
Before storm street (lbs)	2.7	0.44	0.73	0.54	0.62	0.43	0.45	0.34	0.72	0.62
After storm street (lbs)	0.33	0.37	0.45	0.38	0.75	0.20	0.23	0.24	0.51	0.04
△ street (lbs)	2.3	0.07	0.28	0.16	-0.14	0.24	0.22	0.11	0.21	0.58
Run-off yield (lbs)	-	-	0.30	1.8	0.27	0.10	0.50	0.042	0.22	0.21
Before/after ratio	8.2	1.2	1.6	1.4	0.83	2.2	2.0	1.4	1.4	16
Before/yield ratio	-	-	2.4	0.3	2.3	4.3	0.9	8.1	3.3	3.0
△ street/yield ratio	-	-	0.93	0.09	-0.52	2.4	0.44	2.6	0.96	2.8
COPPER:										
Before storm street (lbs)	10.6	1.7	3.3	2.3	2.5	3.1	2.9	2.1	2.2	1.8
After storm street (lbs)	1.2	1.5	1.9	1.5	3.2	1.3	1.5	1.5	1.3	0.62
△ street (lbs)	9.4	0.2	1.4	0.8	-0.7	1.8	1.4	0.6	0.91	1.2
Run-off yield (lbs)	-	-	2.3	13	2.2	1.2	2.9	0.7	38	15
Before/after ratio	8.8	1.1	1.7	1.5	0.78	2.4	1.9	1.4	1.7	2.9
Before/yield ratio	-	-	1.4	0.18	1.1	2.6	1.0	3.0	0.06	0.12
△ street/yield ratio	-	-	0.61	0.06	-0.30	1.5	0.48	0.83	0.02	0.08

△ street - before storm street loading minus the after storm street loading.

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

	STORM CODE:								
	4	5	6	7	8	9	10	11	12 & 13
TOTAL P:									
Before storm street (lbs)	7	6	14	9	9	13	7	7	4
After storm street (lbs)	6	4	8	6	9	8	5	3	7
△ street (lbs)	1	2	6	3		6	2	4	-2
Run-off yield (lbs)	11	14	-	164	16	215	389	11	-
Before/after ratio	1.1	1.7	1.8	1.5	1.0	1.7	1.3	2.5	0.6
Before/yield ratio	0.62	0.42	-	0.06	0.55	0.06	0.02	0.71	-
△ street/yield ratio	0.07	0.17	-	0.02		0.03	0.004	0.42	-
O-PO4:									
Before storm street (lbs)	0.3	0.3	0.7	0.4	0.4	0.6	0.3	0.3	0.3
After storm street (lbs)	0.2	0.1	0.3	0.3	0.4	0.4	0.2	0.1	0.3
△ street (lbs)	0.04	0.15	0.3	0.08	0.03	0.3	0.07	0.2	-0.04
Run-off yield (lbs)	9	14	-	392	9.7	313	466	39	-
Before/after ratio	1.2	2.1	2.0	1.3	1.1	1.8	1.3	2.5	0.9
Before/yield ratio	0.03	0.02	-	0.001	0.04	0.002	0.001	0.009	-
△ street/yield ratio	0.004	0.01	-	0.0002	0.003	0.001	0.0002	0.005	-
ARSENIC:									
Before storm street (lbs)	0.17	0.20	0.33	0.22	0.25	0.32	0.15	0.17	0.14
After storm street (lbs)	0.13	0.08	0.13	0.12	0.12	0.16	0.09	0.05	0.13
△ street (lbs)	0.04	0.12	0.20	0.10	0.13	0.17	0.06	0.12	0.01
Run-off yield (lbs)	0.04	0.07	-	1.8	0.13	1.8	3.7	0.26	-
Before/after ratio	1.3	2.4	2.5	1.8	2.1	2.0	1.6	3.5	1.1
Before/yield ratio	4.7	3.1	-	0.12	1.9	0.18	0.04	0.65	-
△ street/yield ratio	1.0	1.8	-	0.06	0.97	0.09	0.02	0.47	-
COPPER:									
Before storm street (lbs)	1.0	1.1	3.0	2.1	1.8	2.8	1.6	1.8	1.3
After storm street (lbs)	0.7	0.5	1.7	1.4	1.9	1.6	1.1	0.7	1.5
△ street (lbs)	0.3	0.6	1.3	0.7	-0.08	1.2	0.5	1.2	-0.2
Run-off yield (lbs)	8	3.9	-	6.3	18	4.6	29	3.1	3.7
Before/after ratio	1.5	2.3	1.8	1.5	0.9	1.8	1.5	2.8	0.9
Before/yield ratio	0.13	0.28	-	0.33	0.10	0.61	0.06	0.58	0.35
△ street/yield ratio	0.04	0.16	-	0.11	-0.004	0.27	0.02	0.37	-0.06

△ street - before storm street loading minus the after storm street loading .

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

STORM CODE:	14	15	16 & 17	Min.	Max.	Avg.	Avg. lb/curb-Mile
TOTAL P:							
Before storm street (lbs)	11	13	15	4	66	15	0.29
After storm street (lbs)	8	11	11	3	18	8.4	0.16
△ street (lbs)	3	2	4	-3	58	6.6	0.13
Run-off yield (lbs)	-	-	-	5.8	389	79	1.5
Before/after ratio	1.4	1.2	1	0.6	8.3	1.8	-
Before/yield ratio	-	-	-	0.02	2.7	0.7	-
△ street/yield ratio	-	-	-	-0.23	1.4	0.3	-
O-PO4:							
Before storm street (lbs)	0.5	0.6	0.9	0.3	5.1	1.0	0.019
After storm street (lbs)	0.3	0.5	0.5	0.1	1.4	0.5	0.010
△ street (lbs)	0.14	0.13	0.37	-0.2	4.5	0.5	0.010
Run-off yield (lbs)	-	-	-	0.9	466	101	1.9
Before/after ratio	1.4	1.3	1.7	0.86	8.5	2.0	-
Before/yield ratio	-	-	-	0.001	1.7	0.19	-
△ street/yield ratio	-	-	-	-0.004	0.49	0.06	-
ARSENIC:							
Before storm street (lbs)	0.26	0.28	0.46	0.14	2.7	0.5	0.010
After storm street (lbs)	0.13	0.18	0.24	0.04	0.75	0.2	0.004
△ street (lbs)	0.13	0.10	0.22	-0.14	2.3	0.3	0.006
Run-off yield (lbs)	-	-	-	0.04	3.7	0.7	0.014
Before/after ratio	2.0	1.6	1.9	0.83	16	2.7	-
Before/yield ratio	-	-	-	0.04	8.1	2.4	-
△ street/yield ratio	-	-	-	-0.52	2.8	0.9	-
COPPER:							
Before storm street (lbs)	2.4	2.9	4.6	1.0	10.6	2.3	0.044
After storm street (lbs)	1.8	2.6	2.7	0.5	3.2	1.5	0.029
△ street (lbs)	0.6	0.3	1.9	-0.7	9.4	0.8	0.015
Run-off yield (lbs)	-	-	-	0.7	38	9.5	0.18
Before/after ratio	1.3	1.1	1.7	0.78	8.8	2.0	-
Before/yield ratio	-	-	-	0.06	3.0	0.7	-
△ street/yield ratio	-	-	-	-0.30	1.5	0.3	-

△ street - before storm street loading minus the after storm street loading.

TABLE D-4. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR TOTAL SOLIDS

Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	MONTHLY STREET CLEANING Savings (lbs/curb mile)	MONTHLY STREET CLEANING Max. runoff load savings (lbs.)	MONTHLY STREET CLEANING Min. new Runoff Load (lbs.)	MONTHLY STREET CLEANING Max. Runoff Imprvmt. (%)	WEEKLY STREET CLEANING Savings (lbs/curb mile)	WEEKLY STREET CLEANING Max. runoff load savings (lbs.)	WEEKLY STREET CLEANING Min. new Runoff Load (lbs.)	WEEKLY STREET CLEANING Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	112,000	1,280	330	17,000	94,900	2	630	32,600	79,400	29
D & E	1/10-14	1	65,600	298	0	0	65,600	0	0	0	65,600	0
F	2/13-14	27	8,000	720	0	0	8,000	0	70	3,620	4,380	45
G,H,I,J	2/15-22	2	119,000	524	0	0	119,000	0	0	0	119,000	0
K	2/28-3/1	5	12,300	565	0	0	12,300	0	0	0	12,300	0
L	3/15-17	15	6,990	847	0	0	6,990	0	197	10,200	- 3,210	100
M	3/26-28	10	26,500	870	0	0	26,500	0	220	11,400	15,100	43
N	4/26	31	4,970	650	0	0	4,970	0	0	0	4,970	0
1	10/18-19	175	26,500	628	0	0	26,500	0	0	0	26,500	0
3	11/3	9	51,500	539	0	0	51,500	0	0	0	51,500	0
4	11/16-17	13	6,890	256	0	0	6,890	0	0	0	6,890	0
5	11/22-25	6	9,090	291	0	0	9,090	0	0	0	9,090	0
6	12/19-20	25	4,710	637	0	0	4,710	0	0	0	4,710	0
7	12/23-25	4	48,100	414	0	0	48,100	0	0	0	48,100	0
8	12/30-31	5	14,400	414	0	0	14,400	0	0	0	14,400	0
1980												
9	1/8-17	8	128,000	594	0	0	128,000	0	0	0	128,000	0
10	2/14-24	30	217,000	316	0	0	217,000	0	0	0	217,000	0
11	2/27-28	6	33,700	342	0	0	33,700	0	0	0	33,700	0
12 & 13	3/2-6	4	44,500	261	0	0	44,500	0	0	0	44,500	0
14	3/25	19	688	468	0	0	688	0	0	0	688	0
15	4/4-5	10	10,100	587	0	0	10,100	0	0	0	10,100	0
16 & 17	4/20-22	15	11,500	843	0	0	11,500	0	193	9,980	1,520	87
Avg.or Total			962,000			17,000	945,000	0.2		67,800	894,000	7
Minimum												
Maximum												

TABLE D-4. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR TOTAL SOLIDS

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	112,0001	1,280	830	42,900	69,100	38	930	48,100	63,900	43
D & E	1/10-14	1	65,600	298	0	0	65,600	0	0	0	65,600	0
F	2/13-14	27	8,000	720	270	13,900	- 5,960	174	370	19,100	- 11,100	240
G,H,I,J	2/15-22	2	119,000	524	74	3,830	115,000	3	174	9,000	110,000	8
K	2/28-3/1	5	12,300	565	115	5,950	6,350	48	215	11,100	1,180	90
L	3/15-17	15	6,990	847	397	20,500	-20,500	290	497	25,700	- 18,700	370
M	3/26-28	10	26,500	870	420	21,700	4,790	82	520	26,900	- 380	100
N	4/26	31	4,970	650	200	10,300	- 5,370	210	300	15,500	- 10,500	310
1	10/18-19	175	26,500	628	178	9,200	17,300	35	278	14,400	12,100	54
3	11/3	9	51,500	539	89	4,600	46,900	9	189	9,780	41,700	19
4	11/16-17	13	6,890	256	0	0	6,890	0	0	0	6,890	0
5	11/22-25	6	9,090	291	0	0	9,090	0	0	0	9,090	0
6	12/19-20	25	4,710	637	187	9,670	- 4,960	210	287	14,800	- 10,100	310
7	12/23-25	4	48,100	414	0	0	48,100	0	64	3,300	44,800	7
8	12/30-31	5	14,400	414	0	0	14,400	0	64	3,300	11,100	23
1980												
9	1/8-17	8	128,000	594	144	7,440	121,000	6	244	12,600	115,000	10
10	2/14-24	30	217,000	316	0	0	217,000	0	0	0	217,000	0
11	2/27-28	6	33,000	342	0	0	33,700	0	0	0	33,700	0
12 & 13	3/2-6	4	44,500	261	0	0	44,500	0	0	0	44,500	0
14	3/25	19	688	468	18	930	- 240	135	118	6,100	- 5,400	890
15	4/4-5	10	10,100	587	137	7,080	3,020	70	237	12,300	- 2,150	120
16 & 17	4/10-22	15	11,500	843	393	20,300	- 8,820	180	493	25,500	- 14,000	220
Avg.or Total			962,0900			178,000	784,000	19		257,480	704,000	27
Minimum												
Maximum												

TABLE D-5. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR LEAD

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	19	1.22	0	0	19	0	0.24	12	7	63
G,H,I,J	2/15-22	2	80	0.75	0	0	80	0	0	0	80	0
K	2/28-3/1	5	9.6	0.97	0	0	9.6	0	0	0	10	0
L	3/15-17	15	6.7	1.33	0	0	6.7	0	0.35	18	-11	270
M	3/26-28	10	21	1.26	0	0	21	0	0.28	14	7	67
N	4/26	31	8.2	0.91	0	0	8.2	0	0	0	8	0
1	10/18-19	175	179	1.41	0.01	0.5	178	0.3	0.43	22	157	12
3	11/3	9	104	1.10	0	0	104	0	0.12	6	98	6
4	11/16-17	13	29	0.44	0	0	29	0	0	0	29	0
5	11/22-25	6	29	0.48	0	0	29	0	0	0	29	0
6	12/19-20	25	22	0.91	0	0	22	0	0	0	22	0
7	12/23-25	4	38	0.50	0	0	38	0	0	0	38	0
8	12/30-31	5	32	0.56	0	0	32	0	0	0	32	0
1980												
9	1/8-17	8	36	0.81	0	0	36	0	0	0	36	0
10	2/14-24	30	286	0.48	0	0	286	0	0	0	286	0
11	2/27-28	6	18	0.50	0	0	18	0	0	0	18	0
12 & 13	3/2-6	4	28	0.41	0	0	28	0	0	0	28	0
14	3/25	19	1.8	0.77	0	0	1.8	0	0	0	2	0
15	4/4-5	10	14	0.83	0	0	14	0	0	0	14	0
16 & 17	4/20-22	15	15	1.35	0	0	15	0	0.37	19	- 4	130
Avg.or Total		19	976	0.85		0.5	976	0.05		91	886	9
Minimum			49									
Maximum												

TABLE D-5. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR LEAD (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	19	1.22	0.54	28	- 9	150	0.69	36	- 17	190
G,H,I,J	2/15-22	2	90	0.75	0.07	4	76	5	0.22	12	69	15
K	2/28-3/1	5	9.6	0.97	0.29	15	- 5	150	0.44	23	- 13	240
L	3/15-17	15	6.7	1.33	0.65	34	- 27	500	0.80	41	- 35	610
M	3/26-28	10	21	1.26	0.58	30	- 9	140	0.73	38	- 17	180
N	4/26	31	8.2	0.91	0.23	12	- 4	150	0.38	20	- 11	240
1	10/18-19	175	179	1.41	0.73	38	140	21	0.88	46	134	26
3	11/3	9	104	1.10	0.42	22	82	21	0.57	29	75	28
4	11/16-17	13	29	0.44	0	0	29	0	0	0	29	0
5	11/22-25	6	29	0.48	0	0	29	0	0	0	29	0
6	12/19-20	25	22	0.91	0.23	12	10	55	0.38	20	2	91
7	12/23-25	4	38	0.50	0	0	38	0	0	0	38	0
8	12/30-31	5	32	0.56	0	0	32	0	0.03	2	30	6
1980												
9	1/8-17	8	36	0.81	0.13	7	29	19	0.28	14	22	39
10	2/14-24	30	286	0.48	0	0	286	0	0	0	286	0
11	2/27-28	6	18	0.50	0	0	18	0	0	0	18	0
12 & 13	3/2-6	4	28	0.41	0	0	28	0	0	0	28	0
14	3/25	19	1.8	0.77	0.09	5	- 3	280	0.24	12	- 11	670
15	4/4-5	10	14	0.83	0.15	8	6	57	0.30	16	- 2	110
16 & 17	4/20-22	15	15	1.35	0.67	35	- 20	230	0.82	42	- 27	280
Avg.or Total		19	976	0.85		250	726	26		351	627	36
Minimum			49									
Maximum												

TABLE D-6. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ARSENIC

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	0.30	0.013	0	0		0	0.0039	0.22	0.083	73
G,H,I,J	2/15-22	2	1.8	0.010	0	0		0	0.0009	0.05	1.7	3
K	2/28-3/1	5	0.27	0.011	0	0		0	0.0019	0.11	0.16	41
L	3/15-17	15	0.10	0.0077	0	0		0	0	0	0.16	0
M	3/26-28	10	0.50	0.0081	0	0		0	0	0	0.16	0
N	4/26	31	0.04	0.0061	0	0		0	0	0	0.16	0
1	10/18-19	175	0.22	0.013	0	0		0	0.0039	0.22	0	100
3	11/3	9	0.21	0.011	0	0		0	0.0019	0.11	0.10	52
4	11/16-17	13	0.036	0.0031	0	0		0	0	0	0.10	0
5	11/22-25	6	0.065	0.0036	0	0		0	0	0	0.10	0
6	12/19-20	25										
7	12/23-25	4	1.8	0.0039	0	0		0	0	0	0.10	0
8	12/30-31	5	0.13	0.0045	0	0		0	0	0	0.10	0
1980												
9	1/8-17	8	1.8	0.0057	0	0		0	0	0	0.10	0
10	2/14-24	30	3.7	0.0027	0	0		0	0	0	0.10	0
11	2/27-28	6	0.26	0.0031	0	0		0	0	0	0.10	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			11.2			0		0%		0.71	10.5	6%
Minimum			0.75									
Maximum			N=15									

TABLE D-6. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ARSENIC (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	0.030	0.013	0.0067	0.037	-0.07	123	0.0081	0.45	-0.15	150
G,H,I,J	2/15-22	2	1.8	0.010	0.0037	0.21	1.6	12	0.0051	0.28	1.5	16
K	2/28-3/1	5	0.27	0.011	0.0047	0.26	0.008	96	0.0061	0.34	-0.07	125
L	3/15-17	15	0.10	0.0077	0.0014	0.078	0.022	78	0.0028	0.16	-0.06	160
M	3/26-28	10	0.50	0.0081	0.0018	0.10	0.40	20	0.0032	0.18	0.32	36
N	4/26	31	0.04	0.0061	0	0	0.40	0	0.0012	0.07	-0.03	175
1	10/18-19	175	0.22	0.013	0.0067	0.37	-0.15	170	0.0081	0.45	-0.23	200
3	11/3	9	0.21	0.011	0.0047	0.26	-0.052	124	0.0061	0.34	-0.13	160
4	11/16-17	13	0.036	0.0031	0	0	-0.052	0	0	0	-0.13	0
5	11/22-25	6	0.065	0.0036	0	0	-0.052	0	0	0	-0.13	0
6	12/19-20	25										
7	12/23-25	4	1.8	0.0039	0	0	-0.052	0	0	0	-0.13	0
8	12/30-31	5	0.13	0.0045	0	0	-0.052	0	0	0	-0.13	0
1980												
9	1/8-17	8	1.8	0.0057	0	0	-0.052	0	0.0008	0.04	1.8	2
10	2/14-24	30	3.7	0.0027	0	0	-0.052	0	0	0	1.8	0
11	2/27-28	6	0.26	0.0031	0	0	-0.052	0	0	0	1.8	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			11.2			1.7	9.6	15%		2.3	8.9	21%
Minimum			0.75									
Maximum			N=15									

TABLE D-7. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR COPPER

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	2.3	0.059	0	0	2.3	0	0.007	0.39	1.9	17
G,H,I,J	2/15-22	2	13	0.041	0	0	13	0	0	0	Same	0
K	2/28-3/1	5	2.2	0.045	0	0	2.2	0	0	0		0
L	3/15-17	15	1.2	0.056	0	0	1.2	0	0.004	0.22	15	18
M	3/26-28	10	2.9	0.052	0	0	2.9	0	0	0	Same	0
N	4/26	31	0.7	0.038	0	0	0.7	0	0	0	Same	0
1	10/18-19	175	38	0.040	0	0	38	0	0	0	Same	0
3	11/3	9	15	0.032	0	0	15	0	0	0	Same	0
4	11/16-17	13	7.9	0.018	0	0	7.9	0	0	0	Same	0
5	11/22-25	6	3.9	0.020	0	0	3.9	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4	6.3	0.038	0	0	6.3	0	0	0	Same	0
8	12/30-31	5	18	0.032	0	0	18	0	0	0	Same	0
1980												
9	1/8-17	8	4.6	0.050	0	0	4.6	0	0	0	Same	0
10	2/14-24	30	29	0.029	0	0	29	0	0	0	Same	0
11	2/27-28	6	3.1	0.032	0	0	3.1	0	0	0	Same	0
12 & 13	3/2-6	4	3.7	0.023	0	0	3.7	0	0	0	Same	0
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg. or Total			152			0	152	0		0.61	151	<1%
Minimum												
Maximum			N=16									

TABLE D-7. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR COPPER (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	2.3	0.059	0.023	1.3	1.0	57	0.031	1.7	0.6	74
G,H,I,J	2/15-22	2	13	0.041	0.005	0.28	13	2	0.013	0.7	12	5
K	2/28-3/1	5	2.2	0.045	0.009	0.50	1.7	23	0.017	0.95	1.3	43
L	3/15-17	15	1.2	0.056	0.020	1.1	0.09	92	0.028	1.6	-0.36	130
M	3/26-28	10	2.9	0.052	0.016	0.89	2.0	31	0.024	1.3	1.6	45
N	4/26	31	0.7	0.038	0.002	0.11	-0.[illegible]	16	0.010	0.56	0.14	80
1	10/18-19	175	38	0.040	0.004	0.22	38	6	0.012	0.67	37	2
3	11/3	9	15	0.032	0	0	Same	0	0.004	0.22	15	1
4	11/16-17	13	7.9	0.018	0	0	Same	0	0	0	Same	0
5	11/22-25	6	3.9	0.020	0	0	Same	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4	6.3	0.038	0.002	0.11	6.2	2	0.010	0.56	5.7	9
8	12/30-31	5	18	0.032	0	0	Same	6	0.004	0.22	18	1
1980												
9	1/8-17	8	4.6	0.050	0.014	0.78	3.8	17	0.022	1.2	3.4	26
10	2/14-24	30	29	0.029	0	0	Same	0	0.001	0.056	29	<1
11	2/27-28	6	3.1	0.032	0	0	Same	0	0.004	0.22	2.9	7
12 & 13	3/2-6	4	3.7	0.023	0	0	Same	0	0	0	Same	0
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			152			5.3	147	3%		10	142	7%
Minimum												
Maximum			N=16									

TABLE D-8. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ZINC

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. ($)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. ($)
1979												
C	1/8	1	70	0.58	0.34	19	51	0	0.42	23	47	33
D & E	1/10-14	1	42	0.088	0	0	41	0	0	0	41	0
F	2/13-14	27	9.6	0.18	0	0	9.6	0	0.02	1.1	8.4	12
G,H,I,J	2/15-22	2	54	0.13	0	0	54	0	0	0	54	0
K	2/28-3/1	5	9.9	0.15	0	0	9.9	0	0	0	9.9	0
L	3/15-17	15	4.5	0.22	0	0	4.5	0	0.06	3.3	1.2	73
M	3/25-28	10	14	0.22	0	0	14	0	0.06	3.3	11	24
N	4/26	31	4.1	0.15	0	0	4.1	0	0	0	4.1	0
1	10/18-19	175	119	0.17	0	0	119	0	0.01	0.6	118	0.5
3	11/3	9	77	0.14	0	0	77	0	0	0	77	0
4	11/16-17	13	12	0.059	0	0	12	0	0	0	12	0
5	11/22-25	6	16	0.061	0	0	16	0	0	0	16	0
6	12/19-20	25	13	0.13	0	0	13	0	0	0	13	0
7	12/23-25	4	51	0.066	0	0	51	0	0	0	51	0
8	12/30-31	5	20	0.074	0	0	20	0	0	0	20	0
1980												
9	1/8-17	8	31	0.010	0	0	31	0	0	0	31	0
10	2/14-24	30	30	163	0.065	0	163	0	0	0	163	0
11	2/27-28	6	6	16	0	0	16	0	0	0	16	0
12 & 13	3/2-6	4	21	0.025	0	0	21	0	0	0	21	0
14	3/25	19	1.3	0.10	0	0	1.3	0	0	0	1.3	0
15	4/4-5	10	22	0.11	0	0	22	0	0	0	22	0
16 & 17	4/20-22	15	9.3	0.20	0	0	7.1	0	0.04	2.2	7.1	24
Avg.or Total			779	0.14		19	728	2		34	746	4
Minimum			35	0.052								
Maximum				0.58								

TABLE D-8. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ZINC (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	70	0.58	0.47	26	44	37	0.49	27	43	39
D & E	1/10-14	1	41	0.088	0	0	41	0	0	0	41	0
F	2/13-14	27	9.6	0.18	0.07	3.9	5.7	41	0.09	5.1	4.5	53
G,H,I,J	2/15-22	2	54	0.13	0.02	1.1	53	2	0.04	2.3	52	4
K	2/28-3/1	5	9.9	0.15	0.04	2.2	7.7	22	0.06	3.5	6.4	35
L	3/15-17	15	4.5	0.22	0.11	6.1	-1.6	135	0.13	7.4	-2.9	160
M	3/26-28	10	14	0.22	0.11	6.1	7.9	44	0.13	7.4	6.6	53
N	4/26	31	4.1	0.15	0.04	2.2	1.9	54	0.06	3.5	0.6	85
1	10/18-19	175	119	0.17	0.06	3.3	116	3	0.08	4.6	114	4
3	11/3	9	77	0.14	0.03	1.7	75	2	0.05	2.9	74	4
4	11/16-17	13	12	0.059	0	0	12	0	0	0	77	0
5	11/22-25	6	16	0.061	0	0	16	0	0	0	12	0
6	12/19-20	25	13	0.13	0.02	1.1	12	9	0.04	2.3	11	18
7	12/23-25	4	51	0.066	0	0	51	0	0	0	51	0
8	12/30-31	5	20	0.074	0	0	20	0	0	0	20	0
1980												
9	1/8-17	8	31	0.10	0	0	31	0	0.01	0.7	30	0
10	2/14-24	30	163	0.065	0	0	163	0	0	0	163	0
11	2/27-28	6	16	0.066	0	0	16	0	0	0	16	0
12 & 13	3/2-6	4	21	0.052	0	0	21	0	0	0	21	0
14	3/25	19	1.3	0.10	0	0	1.3	0	0.01	0.7	0.6	54
15	4/4-5	10	22	0.11	0	0	22	0	0.02	1.2	21	6
16 & 17	4/20-22	15	9.3	0.20	0.09	5.0	4.3	54	0.11	6.2	3.1	67
Avg.or Total			779	0.14		59	720	8		75	704	10
Minimum			35	0.051								
Maximum				0.58								

TABLE D-9. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR COD (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	20,000	190	149	8,300	11,700	42	156	8,800	11,200	44
D & E	1/10-14	1										
F	2/13-14	27	7,200	55	14	780	6,400	11	23	1,280	5,900	18
G,H,I,J	2/15-22	2	22,600	39	0	0	22,600	0	7	390	22,200	2
K	2/28-3/1	5	3,710	43	2	110	3,600	3	11	610	3,100	16
L	3/15-17	15	2,490	67	26	1,450	1,040	58	35	1,950	540	78
M	3/26-28	10	7,400	71	30	1,670	5,730	23	39	2,170	5,230	29
N	4/26	31	2,020	51	10	560	1,460	28	19	1,060	960	53
1	10/18-19	175	12,400	88	47	2,620	9,780	21	56	3,120	9,280	25
3	11/3	9	16,700	73	32	1,780	14,900	11	41	2,280	14,400	14
4	11/16-17	13	5,020	21	0	0	5,020	0	0	0	5,020	0
5	11/22-25	6	4,220	26	0	0	4,220	0	0	0	4,220	0
6	12/19-20	25										
7	12/23-25	4	15,700	37	0	0	15,700	0	5	280	15,400	2
8	12/30-31	5	4,090	39	0	0	4,090	0	7	390	3,700	10
1980												
9	1/8-11	8	19,300	52	11	610	18,700	3	20	1,110	18,200	6
10	2/14-24	30	50,400	22	0	0	50,400	0	0	0	50,400	0
11	2/27-28	6	7,300	25	0	0	7,300	0	0	0	7,300	0
12 & 13	3/2-6	4	10,900	20	0	0	10,900	0	0	0	10,900	0
14	3/25	19										
15	4/4-5	10	7,590	45	4	220	7,370	3	13	720	6,890	10
16 & 17	4/20-22	15										
Avg.or Total			219,000	54		18,100	200,000	8%		24,200	195,000	11%
Minimum			12,200	20								
Maximum			[illegible]	190								

TABLE D-9. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR COD

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	20,000	190	104	5,800	14,200	29	131	7,300	12,700	37
D & E	1/10-14	1										
F	2/13-14	27	7,200	55	0	0	Same	0	0	0	7,200	0
G,H,I,J	2/15-22	2	22,600	39	0	0	Same	0	0	0	22,600	0
K	2/28-3/1	5	3,710	43	0	0	Same	0	0	0	3,710	0
L	3/15-17	15	2,490	67	0	0	Same	0	8	450	2,040	18
M	3/26-28	10	7,400	71	0	0	Same	0	12	670	6,730	9
N	4/26	31	2,020	51	0	0	Same	0	0	0	2,020	0
1	10/18-19	175	12,400	88	2	111	12,300	1	29	1,620	10,800	13
3	11/3	9	16,700	73	0	0	Same	0	14	780	15,900	5
4	11/16-17	13	5,020	21	0	0	Same	0	0	0	5,020	0
5	11/22-25	6	4,220	26	0	0	Same	0	0	0	4,220	0
6	12/19-20	25										
7	12/23-25	4	15,700	37	0	0	Same	0	0	0	15,700	0
8	12/30-31	5	4,090	39	0	0	Same	0	0	0	4,090	0
1980												
9	1/8-17	8	19,300	52	0	0	Same	0	0	0	19,300	0
10	2/14-24	30	50,400	22	0	0	Same	0	0	0	50,400	0
11	2/27-28	6	7,300	25	0	0	Same	0	0	0	7,300	0
12 & 13	3/2-6	4	10,900	20	0	0	Same	0	0	0	10,900	0
14	3/25	19										
15	4/4-5	10	7,590	45	0	0	Same	0	0	0	7,590	0
16 & 17	4/20-22	15										
Avg.or Total			219,000	54		5,910	213,000	3%		10,800	208,000	5%
Minimum			12,200	20								
Maximum			#:18	190								

TABLE D-10. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR PHOSPHORUS

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	130	1.2	0.75	42	88	32	0.89	50	80	38
D & E	1/10-14	1										
F	2/13-14	27	23	0.34	0	0	88	0	0.03	1.7	21	7
G,H,I,J	2/15-22	2	130	0.23	0	0	88	0	0	0	21	0
K	2/28-3/1	5	13	0.27	0	0	88	0	0	0	21	0
L	3/15-17	15	6.7	0.32	0	0	88	0	0.01	0.6	6	9
M	3/26-28	10	38	0.32	0	0	88	0	0.01	0.6	37	2
N	4/26	31	5.8	0.25	0	0	88	0	0	0	37	0
1	10/18-19	175	44	0.34	0	0	88	0	0.03	1.7	42	4
3	11/3	9	58	0.29	0	0	88	0	0	0	42	0
4	11/16-17	13	11	0.12	0	0	88	0	0	0	42	0
5	11/22-25	6	14	0.11	0	0	88	0	0	0	42	0
6	12/19-20	25										
7	12/23-25	4	164	0.17	0	0	88	0	0	0	42	0
8	12/30-31	5	16	0.16	0	0	83	0	0	0	42	0
1980												
9	1/8-17	8	215	0.23	0	0	88	0	0	0	42	0
10	2/14-24	30	389	0.13	0	0	88	0	0	0	42	0
11	2/27-28	6	11	0.13	0	0	88	0	0	0	42	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			1,270			42	1230	3		55	1,220	4
Minimum			79									
Maximum			u = 16									

TABLE D-10. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR PHOSPHORUS (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	130	1.2	1.0	56	74	43	1.0	58	72	45
D & E	1/10-14	1										
F	2/13-14	27	23	0.34	0.13	7.2	16	31	0.18	10	13	43
G,H,I,J	2/15-22	2	130	0.23	0.02	1.1	129	1	0.07	3.9	126	3
K	2/28-3/1	5	13	0.27	0.06	3.3	9.7	25	0.11	6.1	6.9	47
L	3/15-17	15	6.7	0.32	0.11	6.1	0.6	91	0.16	8.9	-22	130
M	3/26-28	10	38	0.32	0.11	6.1	32	16	0.16	8.9	29	23
N	4/26	31	5.8	0.25	0.04	2.2	3.6	38	0.09	5.0	0.8	86
1	10/18-19	175	44	0.34	0.13	7.2	37	16	0.18	10	34	23
3	11/3	9	58	0.29	0.08	4.5	54	8	0.13	7.2	51	12
4	11/16-17	13	11	0.12	0	0	54	0	0	0	51	0
5	11/22-25	6	14	0.11	0	0	54	0	0	0	51	0
6	12/19-20	25										
7	12/23-25	4	164	0.17	0	0	54	0	0.01	0.6	163	0.3
8	12/30-31	5	16	0.16	0	0	54	0	0	0	163	0
1980												
9	1/8-17	8	215	0.23	0.02	1.1	214	0	0.07	3.9	211	2
10	2/14-24	30	389	0.13	0	0	214	0	0	0	211	0
11	2/27-28	6	11	0.13	0	0	214	0	0	0	211	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			1,270			95	1,180	7		124	1,150	10
Minimum			79									
Maximum			u = 16									

TABLE D-11. **MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ORTHO PHOSPHATE**

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	29	0.025	0	0	Same	0	0.005	0.28	29	1
G,H,I,J	2/15-22	2	260	0.018	0	0	Same	0	0	0	Same	0
K	2/28-3/1	5	8.9	0.022	0	0	Same	0	0.002	0.11	8.8	1
L	3/15-17	15	2.9	0.034	0.005	0.28	2.6	10	0.014	0.78	2.1	27
M	3/26-28	10	15	0.036	0.007	0.39	15	3	0.016	0.89	14	6
N	4/26	31	0.9	0.029	0	0	Same	0	0.009	0.50	0.4	56
1	10/18-19	175	35	0.016	0	0	Same	0	0	0	Same	0
3	11/3	9	29	0.014	0	0	Same	0	0	0	Same	0
4	11/16-17	13	9.0	0.0048	0	0	Same	0	0	0	Same	0
5	11/22-25	6	14	0.0052	0	0	Same	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4	390	0.0066	0	0	Same	0	0	0	Same	0
8	12/30-31	5	9.7	0.0075	0	0	Same	0	0	0	Same	0
1980												
9	1/8-17	8	310	0.011	0	0	Same	0	0	0	Same	0
10	2/14-24	30	466	0.0054	0	0	Same	0	0	0	Same	0
11	2/27-28	6	39	0.0059	0	0	Same	0	0	0	Same	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			1620			0.67	1620	<<1%		2.6	1620	<1%
Minimum												
Maximum												

TABLE D-11. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR ORTHO PHOSPHATE (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1										
D & E	1/10-14	1										
F	2/13-14	27	29	0.025	0.011	0.61	28	2	0.014	0.78	28	3
G,H,I,J	2/15-22	2	260	0.018	0.004	0.22	260	<<1	0.007	0.39	260	<1
K	2/28-3/1	5	8.9	0.022	0.088	0.45	8.5	5	0.011	0.61	8.3	7
L	3/15-17	15	2.9	0.034	0.020	1.1	1.8	38	0.023	1.3	1.6	45
M	3/26-28	10	15	0.036	0.022	1.2	14	8	0.025	1.4	14	9
N	4/26	31	0.9	0.029	0.015	0.84	0.06	93	0.018	1.0	-0.1	110
1	10/18-19	175	35	0.016	0.002	0.11	35	<1	0.005	0.28	35	1
3	11/3	9	29	0.014	0	0	Same	0	0.003	0.17	29	1
4	11/16-17	13	9.0	0.0048	0	0	Same	0	0	0	Same	0
5	11/22-25	6	14	0.0052	0	0	Same	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4	390	0.0066	0	0	Same	0	0	0	Same	0
8	12/30-31	5	9.7	0.0075	0	0	Same	0	0	0	Same	0
1980			310	0.011	0	0	Same	0	0	0	Same	0
9	1/8-17	8	466	0.0054	0	0	Same	0	0	0	Same	0
10	2/14-24	30	39	0.0059	0	0	Same	0	0	0	Same	0
11	2/27-28	6										
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			1620			4.5	1620	<1%		5.9	1610	<1%
Minimum												
Maximum												

TABLE D-12. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR TKN

					MONTHLY STREET CLEANING				WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	470	1.4	1.4	0	470	0	0.98	23	450	5
D & E	1/10-14	1										
F	2/13-14	27	83	0.41	0	0	83	0	0	0	Same	0
G,H,I,J	2/15-22	2	470	0.29	0	0	470	0	0	0	Same	0
K	2/28-3/1	5	97	0.32	0	0	97	0	0	0	Same	0
L	3/15-17	15	18	0.31	0	0	18	0	0	0	Same	0
M	3/26-28	10	135	0.32	0	0	135	0	0	0	Same	0
N	4/26	31	41	0.23	0	0	41	0	0	0	Same	0
1	10/18-19	175	406	1.1	0	0	406	0	0.12	6.7	400	2
3	11/3	9	293	0.92	0	0	293	0	0	0	Same	0
4	11/16-17	13	61	0.38	0	0	61	0	0	0	Same	0
5	11/22-25	6	78	0.40	0	0	78	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4										
8	12/30-31	5	120	0.54	0	0	120	0	0	0	Same	0
1980												
9	1/8-17	8	530	0.81	0	0	530	0	0	0	Same	0
10	2/14-24	30	1390	0.43	0	0	1390	0	0	0	Same	0
11	2/27-28	6	156	0.45	0	0	156	0	0	0	Same	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			4350			0	4350	0		30	4320	1
Minimum			290									
Maximum			#:15									

TABLE D-12. MAXIMUM RUNOFF YIELD IMPROVEMENTS FOR VARIOUS STREET CLEANING PROGRAMS FOR TKN (continued)

					TWICE WEEKLY STREET CLEANING				THREE TIMES WEEKLY STREET CLEANING			
Storm No.	Storm Date	Preceeding Significant Dry Period (days)	Runoff Yield (lbs.)	Initial Load (lbs/curb mile)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)	Savings (lbs/curb mile)	Max. runoff load savings (lbs.)	Min. new Runoff Load (lbs.)	Max. Runoff Imprvmt. (%)
1979												
C	1/8	1	470	1.4	0.68	40	430	9	0.53	48	420	10
D & E	1/10-14	1										
F	2/13-14	27	83	0.41	0	0	Same	0	0	0	420	0
G,H,I,J	2/15-22	2	470	0.29	0	0	Same	0	0	0	Same	0
K	2/28-3/1	5	97	0.32	0	0	Same	0	0	0	Same	0
L	3/15-17	15	18	0.31	0	0	Same	0	0	0	Same	0
M	3/26-28	10	135	0.32	0	0	Same	0	0	0	Same	0
N	4/26	31	41	0.23	0	0	Same	0	0	0	Same	0
1	10/18-19	175	406	1.1	0.42	23	380	6	0.57	32	370	8
3	11/3	9	293	0.92	0.24	13	280	4	0.39	22	271	8
4	11/16-17	13	61	0.38	0	0	Same	0	0	0	Same	0
5	11/22-25	6	78	0.40	0	0	Same	0	0	0	Same	0
6	12/19-20	25										
7	12/23-25	4										
8	12/30-31	5	120	0.54	0	0	Same	0	0	0	271	0
1980												
9	1/8-17	8	530	0.81	0.13	7.2	523	1	0.28	16	Same	3
10	2/14-24	30	1390	0.43	0	0	Same	0	0	0	510	0
11	2/27-28	6	156	0.45	0	0	Same	0	0	0	Same	0
12 & 13	3/2-6	4										
14	3/25	19										
15	4/4-5	10										
16 & 17	4/20-22	15										
Avg.or Total			4350			83	4270	2		118	4230	3
Minimum			290									
Maximum			15									

APPENDIX E - RAIN, RUNOFF AND BASE FLOW CHARACTERISTICS, URBAN RUNOFF YIELDS, AND RUNOFF HYDROGRAPHS

TABLE E-1. CASTRO VALLEY RAIN EVENTS DURING FIELD ACTIVITIES[1]
YEAR ONE

Date	Total (inches)	Duration (hours)	Average Intensity (inches/hour)	Peak 15-minute Intensity (inches/hour)
Dec. 17, 1978*	0.39	12.5	0.03	0.14
Dec. 18	0.05	15.75	0.003	0.03
Dec. 19	0.01	0.25	0.04	0.04
Jan. 3, 1979	0.10	3.25	0.03	0.03
Jan. 4	0.03	9.25	0.003	0.02
Jan. 5	0.01	0.25	0.04	0.04
Jan. 7*	0.34	14.75	0.02	0.05
Jan. 8*	1.24	6.0	0.21	0.40
Jan. 9	0.18	8.25	0.02	0.04
Jan. 10*	0.78	4.25	0.18	0.39
Jan. 11	1.80	20.75	0.09	0.27
Jan. 14*	1.43	20.75	0.07	0.33
Jan. 15	0.28	12.75	0.02	0.09
Jan. 17	0.24	5.75	0.04	0.11
Jan. 30	0.01	0.25	0.04	0.04
Feb. 3	0.01	0.25	0.04	0.04
Feb. 13*	1.11	13.25	0.08	0.25
Feb. 14	0.09	9.25	0.01	0.01
Feb. 15	0.01	0.25	0.01	0.01
Feb. 16*	0.49	11.75	0.04	0.21
Feb. 17	0.01	0.25	0.04	0.04
Feb. 18	0.45	8.75	0.05	0.20
Feb. 19*	0.06	1.25	0.05	0.05
Feb. 20*	0.74	17.75	0.04	0.25
Feb. 21*	0.41	11.0	0.04	0.17
Feb. 22*	0.64	13.25	0.05	0.30
Feb. 23	0.18	23.25	0.01	0.07
Feb. 25	0.07	2.75	0.03	0.04
Feb. 26	0.09	9.50	0.01	0.06
Feb. 28*	0.58	6.25	0.09	0.17
Mar. 1	0.01	0.25	0.04	0.04
Mar. 3	0.03	4.5	0.01	0.01
Mar. 15	0.05	2.7	0.02	0.04
Mar. 16*	0.69	17.3	0.04	0.15
Mar. 17	0.01	0.25	0.04	0.04
Mar. 26	0.40	13.15	0.03	0.13
Mar. 27*	1.45	23.0	0.06	0.38
Mar. 28	0.13	20.85	0.01	0.06
Apr. 6	0.02	0.25	0.08	0.08
Apr. 9	0.01	0.25	0.04	0.04
Apr. 16	0.05	9.15	0.01	0.04
Apr. 17	0.04	6.15	0.01	0.01
Apr. 22	0.04	1.85	0.02	0.03
Apr. 23	0.11	20.0	0.01	0.09
Apr. 25	0.01	0.25	0.04	0.04
Apr. 26*	0.37	12.15	0.03	0.12
May 5	0.02	0.5	0.04	0.02
May 6	0.05	23.5	0.002	0.03
May 7	0.04	12.75	0.003	0.02
May 8	0.03	2.0	0.015	0.02
May 15	0.01	0.25	0.04	0.40

Station discontinued for remainder of water year.

1/ Proctor Schol Rain Gage, USGS No. 374259122041901

* Monitored Events

TABLE E-1. CASTRO VALLEY RAIN EVENTS DURING FIELD ACTIVITIES[1]
YEAR TWO

Date	Total (inches)	Duration (hours)	Average Intensity (inches/hour)	Peak 15-Minute Intensity
Oct. 15, 1979	.01	.25	.04	.01
Oct. 18*	.15	2.75	.05	.04
Oct. 19*	.84	22.75	.04	.08
Oct. 20*	.02	.25	.08	.01
Oct. 25*	1.68	7.25	.23	.17
Oct. 26	.01	.25	.04	.01
Oct. 30	.03	2.5	.01	.02
Nov. 2	.01	.25	.04	.01
Nov. 3*	.56	14.75	.04	.16
Nov. 4	.01	--	--	--
Nov. 5	.02	6.25	.003	.01
Nov. 7	.03	1.5	.02	.01
Nov. 8	.02	2	.01	.01
Nov. 16*	.78	7	.11	.10
Nov. 17*	.05	3.75	.01	.01
Nov. 22*	.41	6.25	.07	.06
Nov. 24*	.22	11.25	.02	.02
Nov. 25*	.10	3	.03	.02
Dec. 19*	.44	12.75	.03	.05
Dec. 20*	.13	2.25	.06	.03
Dec. 23*	1.59	16	.10	.10
Dec. 24*	1.46	20.25	.07	.08
Dec. 25*	.47	23.25	.02	.06
Dec. 30*	.25	13.5	.02	.03
Dec. 31	.37	13.75	.03	.03
Jan. 1, 1980	.01	.25	.04	.01
Jan. 2	.01	--	--	--
Jan. 4	.01	--	--	--
Jan. 8*	.05	1.75	.03	.02
Jan. 9*	.38	17.25	.02	.04
Jan. 10*	.42	20.25	.02	.04
Jan. 11*	1.22	23.25	.05	.10
Jan. 12*	.24	20.75	.01	.05
Jan. 13*	1.35	21	.06	.20
Jan. 14*	.01	.25	.04	.01
Jan. 15*	.20	16.25	.01	.02
Jan. 16*	.11	12.5	.01	.02
Jan. 17*	.14	10	.01	.02
Jan. 18*				
Feb. 14*	.66	22.5	.03	.04
Feb. 15*	.64	15	.04	.09
Feb. 16*	1.13	16.75	.07	.15
Feb. 17*	.24	19.75	.01	.02
Feb. 18*	.68	23.15	.03	.10
Feb. 19*	1.31	23.75	.06	.13
Feb. 20*	.89	23.75	.04	.13
Feb. 21*	.38	9.25	.04	.11
Feb. 22*	.08	10.25	.01	.02
Feb. 24*	.01	.25	.04	.01
Feb. 27*	.73	8	.09	.25
Feb. 28*	.01	.25	.04	.01
Feb. 29	.01	.25	.04	.01
Mar. 2*	.33	16	.02	.02
Mar. 3*	.05	10.5	.005	.01
Mar. 4*	.28	1.75	.16	.09
Mar. 5*	.32	22	.01	.07
Mar. 6*	.29	6.15	.05	.13
Mar. 11	.01	.25	.04	.01
Mar. 14	.03	1.25	.02	.01
Mar. 15	.01	.25	.04	.01
Mar. 21	.01	.25	.04	.01
Mar. 25*	.19	3.75	.05	.05
Mar. 27	.01	.25	.04	.01
Apr. 4*	.30	--	--	--
Apr. 5*	.76	--	--	--
Apr. 20				
Apr. 21	No data			
Apr. 22				

*Monitored runoff

TABLE E-2. SUMMARY OF MONTHLY URBAN RUNOFF AND RAINFALL VOLUMES

	Monthly Runoff Volumes (Acre-Feet)			Ratio of Runoff Volume to Rainfall Volume		
Month	Overall Range (acre-ft per storm)	Average, Only Runoff Causing Events (acre-ft per storm)	Overall Average (acre-ft per storm)	Overall Range	Average, Only Runoff Causing Events	Overall Average
Oct.	0-152	36	18	<0.02-0.41	0.34	0.17
Nov.	0-33	21	18	<0.02-0.73	0.34	0.29
Dec.	5.1-140	36	36	0.17-0.53	0.30	0.30
Jan.	0-152	67	37	<0.02-0.51	0.34	0.19
Feb.	0-343	170	73	<0.02-0.76	0.53	0.22
Mar.	0-43	22	9	<0.02-0.44	0.25	0.10
Apr.	0-29	9.5	7	<0.02-0.36	0.24	0.17
May	0-1.9	1.9	1	<0.02-0.19	0.19	0.10
June	0	0	0	<0.02	<0.02	<0.02
July	0	0	0	<0.02	<0.02	<0.02
Aug.	0	0	0	<0.02	<0.02	<0.02
Sept.	0	0	0	<0.02	<0.02	<0.02

TABLE E-3. CASTRO VALLEY CREEK OBSERVED BASE FLOW CONCENTRATIONS (mg/l, except for As-Pb, which are ug/l)

	Seaview Station				Knox Station			
Constituent	Min.	Max.	Ave.	No. of Obser.	Min.	Max.	Ave.	No. of Obser.
Total alk., as $CaCO_3$	250	360	300	5	210	300	260	5
Non-carbonate hardness, as $CaCO_3$	67	340	180	5	140	340	250	5
Total hardness, as $CaCO_3$	320	750	490	5	370	600	510	5
Calcium, diss.	74	160	110	5	74	120	100	5
Magnesium, diss.	32	85	50	5	44	76	63	5
Potassium, diss.	1.1	3.4	2.0	5	2.0	4.5	3.4	5
Sodium, diss.	52	160	96	5	92	170	130	5
Chloride, diss.	46	170	100	5	130	300	230	5
Sulfate, diss.	120	450	250	5	150	260	210	5
Total Solids	510	1,400	870	5	690	1,200	1,000	5
Filterable Solids (TDS)	490	1,310	840	5	680	1,100	950	5
Non-filterable Solids (SS)	0	42	14	5	0	11	3	5
Volatile, Non-filterable Solids (VSS)	0	14	7	5	0	5	2	5
COD	14	34	27	5	21	54	34	5
Total Nitrogen	1.3	2.6	1.8	5	1.5	5.8	3.0	5
Organic Nitrogen	0.6	1.2	0.9	5	0.6	1.2	0.9	5
Total Kjeldahl Nitrogen	0.8	1.6	1.3	5	0.6	3.2	1.4	5
Ammonia, as N	0.06	0.5	0.3	5	0	2.4	0.5	5
Nitrites plus Nitrates, as N	0.2	1.2	0.5	5	0.6	2.9	1.6	5
Total Phosphorus	0.03	2.8	1.1	5	0.1	1.2	0.5	4
Diss. Ortho-Phosphates, as PO_4	0	2.9	1.6	3	0.3	2.9	1.2	4
Arsenic	0	3	1.4	5	1	3	2	5
Cadmium	0	1	0.2	5	0	1	0.2	5
Chromium	0	10	6	5	0	20	5	5
Copper	0	20	9	5	0	23	7	5
Iron	800	5,600	2,800	5	170	1,400	560	5
Lead	0	150	38	5	0	76	25	5
Mercury	0.1	1.7	0.5	5	0	2.3	0.7	5
Nickel	0	0	0	5	0	0	0	5
Zinc	30	100	60	5	30	90	70	5

TABLE E-4. CASTRO VALLEY CREEK OBSERVED STORM FLOW CONCENTRATIONS (mg/l, except for arsenic - zinc which are ug/l).

Constituent	Seaview Station						Knox Station					
	Min.	Max.	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	No. of Observ.	Min.	Max	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	No. of Observ.
Total alk., as $CaCO_3$	62	200	117	41	0.4	14	21	91	43	17	0.4	19
Non-carbonate hardness, as $CaCO_3$	13	68	43	16	0.4	14	12	44	22	9	0.4	19
Total hardness, as $CaCO_3$	94	270	160	54	0.3	14	33	120	66	22	0.3	19
Calcium, diss.	24	66	38	13	0.3	14	9	26	16	5	0.3	19
Magnesium, diss.	8.3	25	16	5	0.3	14	1.3	12	6	3	0.5	19
Potassium, diss.	1.9	4.4	2.9	0.7	0.2	14	1.1	16	2.6	3.3	1.3	19
Sodium, diss.	13	79	31	16	0.5	14	6.4	24	13	4.3	0.3	19
Chloride, diss.	15	110	33	23	0.7	15	9	27	17	6	0.3	20
Sulfate, diss.	30	100	57	20	0.4	14	13	43	24	8	0.3	20
Total Solids	402	1,715	910	356	0.4	20	132	730	350	180	0.5	30
Filterable Solids (TDS)	176	495	300	98	0.3	16	73	244	125	43	0.3	21
Non-filterable Solids (SS)	94	1,220	640	375	0.6	16	40	600	250	170	0.7	21
Volatile, non-filterable solids (VSS)	26	138	93	38	0.4	14	0	120	51	35	3.7	19
COD	33	193	110	46	0.4	17	16	230	89	43	0.5	24
Total Nitrogen	2.0	15	5.3	3.4	0.6	15	1.6	9.2	3.3	1.6	0.5	19
Organic Nitrogen	0.8	6.5	3.7	3.3	0.9	15	0.23	24	3.0	4.9	1.6	22
Total Kjeldahl Nitrogen	0.9	14	4.0	3.2	0.8	16	0.65	7.5	2.1	1.5	0.7	22
Ammonia, as N	0.03	0.35	0.16	0.09	0.6	16	0.02	0.37	0.09	0.08	0.8	22
Nitrites plus Nitrates, as N	0.81	4.9	1.5	1.0	0.7	15	0.67	1.9	1.1	0.39	0.4	19
Total Phosphorus	0.08	1.9	0.6	0.5	0.9	16	0.15	0.85	0.42	0.19	0.5	21
Dissolved ortho-phosphates, as PO_4	0.03	0.8	0.4	0.3	0.6	14	0.06	0.95	0.46	0.26	0.6	20
Arsenic	2	9	5	2	0.4	14	1	6	4	2	0.4	20
Cadmium	0	23	3	6	2	15	0	12	3	4	1.4	20
Chromium	0	60	19	18	1.0	15	0	60	13	17	1.3	20
Copper	30	100	56	18	0.3	15	21	700	100	160	1.6	20
Iron	1,900	50,000	25,000	17,000	0.7	15	5,000	21,000	9,300	4,900	0.5	20
Lead	0	600	113	160	1.4	16	97	3,300	490	610	1.3	25
Mercury	0	2.6	0.6	0.8	1.5	14	0	2.5	0.4	0.6	1.5	19
Nickel	0	100	69	42	0.6	14	0	100	37	45	1.2	18
Zinc	60	496	180	122	0.7	20	93	2,200	310	390	1.3	30

TABLE E-5. CASTRO VALLEY CREEK OBSERVED STORM MASS EMISSIONS (lbs/storm).

	Seaview Station				Knox Station						Urban Runoff Only					
Constituent	Min.	Max.	Avg.	No. of Observ.	Min.	Max.	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	No. of Observ.	Min.	Max.	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	No. of Observ.
Total alk., as $CaCO_3$	166	22,000	4,300	14	750	65,000	8,100	15,000	1.9	19	360	43,000	5,000	9,600	1.9	19
Non-carbonate hardness, as $CaCO_3$	63	9,200	1,400	14	310	38,000	4,000	8,400	2.1	19	120	28,600	2,960	6,300	2.1	19
Total hardness, as $CaCO_3$	82	32,000	5,300	15	1,100	100,000	12,000	23,000	1.9	19	485	70,300	7,900	16,000	2.0	19
Calcium, diss.	53	7,200	1,300	14	280	25,000	3,000	5,700	1.9	19	134	17,600	2,000	4,000	1.9	19
Magnesium, diss.	23	3,200	570	14	97	10,000	1,100	2,300	2.0	19	34	6,800	700	1,500	2.2	19
Potassium, diss.	2.0	650	120	14	35	2,000	390	580	1.5	19	21	1,670	300	470	1.6	19
Sodium, diss.	38	5,200	970	14	200	20,000	2,600	4,600	1.8	19	86	14,800	1,700	3,300	2.0	19
Chloride, diss.	41	4,700	870	15	210	24,000	2,800	5,300	1.9	20	78	18,900	2,200	4,200	1.9	20
Sulfate, diss.	80	11,000	2,000	14	190	40,000	4,700	8,900	1.9	20	143	28,700	3,100	6,400	2.1	19
Total Solids	600	190,000	22,000	20	1,500	570,000	55,000	110,000	2.1	30	688	217,000	31,500	47,000	1.5	28
Filterable Solids (TDS)	380	58,000	9,200	16	1,800	190,000	22,000	40,000	1.8	21	770	128,000	16,000	28,000	1.8	20
Non-filterable Solids (SS)	280	300,000	37,000	16	700	350,000	48,000	85,000	1.8	22	370	90,000	21,000	24,000	1.2	20
Volatile Non-filterable Solids (VSS)	130	34,000	4,000	14	0	45,000	8,600	13,000	1.5	19	110	45,000	6,000	10,000	1.7	18
COD	57	30,000	4,300	17	990	80,000	12,000	17,000	1.4	24	990	50,400	8,900	10,000	1.2	24
Total Nitrogen	2.3	1,300	240	15	14	4,100	520	930	1.8	22	39	2,800	400	540	1.6	19
Organic Nitrogen	1.5	920	180	15	19	2,200	410	650	1.6	19	0	1,890	290	420	1.7	20
Total Kjeldahl Nitrogen	1.6	970	170	16	14	2,400	320	550	1.7	22	0	1,390	210	360	1.7	20
Ammonia, as N	0.06	40	6.5	16	0.006	150	17	35	2.1	22	0	110	13	26	2.0	20
Nitrites plus Nitrates, as N	0.37	370	62	15	12	1,800	250	450	1.8	19	11	1,400	200	350	1.8	19
Total Phosphorus	0.34	140	24	16	4.1	530	78	130	1.7	21	5.5	389	60	94	1.5	20
Dissolved Ortho-phosphates, as PO_4	0.03	77	12	14	1.2	540	92	150	1.7	20	1.1	466	87	140	1.6	14
Arsenic	0.003	2.2	0.31	14	0.03	5.9	0.8	1.4	1.8	20	0.03	3.7	0.57	0.9	1.6	20
Cadmium	0	3.6	0.3	15	0	12	1.0	2.8	2.8	20	0	11	0.77	2.5	3.3	20
Chromium	0	2.1	0.4	15	0	6.3	1.2	1.6	1.4	20	0	4.2	1.0	1.3	1.3	10
Copper	0.06	17	2.9	15	1.0	46	9.6	12	1.3	20	0.9	38	7.4	10	1.3	20
Iron	11	12,000	1,800	14	120	150,000	1,800	3,300	1.8	20	98	2,080	560	540	1.0	20
Lead	0	32	4.7	16	2.0	310	42	67	1.6	25	1.8	286	39	64	1.6	25
Mercury	0	0.2	0.03	14	0	0.94	0.09	0.22	2.4	19	0	0.75	0.07	0.2	2.4	19
Nickel	0	25	3.9	14	0	45	4.9	11	2.2	18	0	30	4.0	7.6	1.9	16
Zinc	0.1	50	7.0	19	1.5	210	29	44	1.5	30	1.3	163	26	37	1.4	28

TABLE E-6. RATIO OF URBAN STORM MASS YIELDS TO NON-URBAN STORM MASS YIELDS

	Based on lb/acre/year					
Constituent	Minimum	Maximum	Average	Standard Deviation	St.Dev./ Average Ratio	Number of Observation
Total alk., as $CaCO_3$	0.1	7.1	1.9	2.0	1.0	14
Non-carbonate hardness, as $CaCO_3$	0.4	11	3.1	3.1	1.0	14
Total hardness as $CaCO_3$	0.1	7.9	2.2	2.2	1.0	14
Calcium, diss.	0.1	8.6	2.4	2.4	1.0	14
Magnesium, diss.	0.1	7.1	1.9	2.1	1.1	14
Potassium, diss.	0.9	17	3.4	4.4	1.3	14
Sodium, diss.	0.3	7.9	2.1	2.0	0.9	14
Chloride, diss.	0.4	8.6	2.8	2.6	0.9	15
Sulfate, diss.	0.1	7.1	2.2	2.1	1.0	14
Total Solids	0.4	18	3.1	4.2	1.4	20
Filterable Solids (TDS)	0.3	21	3.4	5.3	1.5	15
Non-filterable Solids (SS)	0.1	17	3.3	4.9	1.5	15
Volatile, Non-filterable Solids (VSS)	0	1,800	120	470	3.7	14
COD	0.6	31	9.3	11	1.1	17
Total Nitrogen	0.1	19	4.5	6.0	1.3	14
Organic Nitrogen	0	31	7.9	11	1.5	14
Total Kjeldahl Nitrogen	0	23	6.6	9.3	1.4	14
Ammonia, as N	0	11	2.9	3.4	1.2	15
Nitrites plus Nitrates, as N	1.3	51	7.9	13	1.6	14
Total Phosphorus	0.5	19	6.1	6.0	1.0	15
Diss. Ortho-Phosphates, as PO_4	0.2	79	14	20	1.5	14
Arsenic	1.1	26	6.0	6.9	1.1	14
Cadmium	0.4	16	4.4	5.9	1.4	6
Chromium	0	10	3.1	3.3	1.1	11
Copper	0.2	19	4.8	5.6	1.2	15
Iron	0.03	14	3.2	4.3	1.3	14
Lead	0.8	10	4.7	3.1	0.7	9
Mercury	0.3	43	11	14	1.2	12
Nickel	0	21	4.3	6.4	1.5	9
Zinc	0.5	40	12	12	1.0	19

TABLE E-7. GROUPINGS OF CONSTITUENTS BY URBAN TO NON-URBAN MASS YIELD RATIOS (on a lb/acre/year basis)

Range of Average Ratios	Constituents
1.4 - 2.4	Total alkalinity Total hardness Calcium Magnesium Sodium Sulfate
2.5 - 3.5	Non-carbonate hardness Potassium Chloride Total solids Filterable solids Non-filterable solids Ammonia Chromium Iron
3.6 - 5.3	Total nitrogen Cadmium Copper Lead Nickel
5.4 - 7.1	Total Kjeldahl nitrogen Total phosphorus Arsenic
7.2 - 14	COD Organic nitrogen Nitrites plus nitrates Dissolved ortho-phosphates Mercury Zinc
>14	Volatile, non-filterable solids

TABLE E-8. URBAN AREA MASS EMISSIONS (lbs/storm)

Storm Date:	Storm Code	Total Alk. as $CaCO_3$	As	Cd	Ca (diss)	Cl (diss)	Cr	COD	Cu	Non-Carbonate Hardness	Total Hardness	Fe	Pb	Mg (diss)	Hg
12/17/78	A		0.03					990							
1/7/79	B							1,160							
1/8/79	C							15,500							
1/10-11	D														
1/14	E														
2/13-14	F	2,400	0.39	0	885	885	0.73	9,220	3.04	1,200	3,580	478	23.9	327	0.03
2/15-16	G	1,220	0.16	0	511	370		1,800	1.59	811	2,038	188	4.12	179	0.0078
2/18-19	H	1,370	0.12	0	535	615	0.27	2,110	1.27	787	2,165	123	7.10	202	0.0067
2/20-21	I	4,027	0.72	0	1,590	1,570	0.43	6,190	4.07	2,410	6,430	291	29.4	601	0.012
2/22	J	2,610	0.71	0	1,230	1,030	4.24	10,000	5.49	1,900	4,500	2,080	47.4	331	0.02
2/28	K	360	0.12	0	134	78	0.37	1,650	0.94	120	485	122	4.72	34.3	0.002
3/15-17	L	903	0.079	0	354	444	0.56	2,170	1.03	1,030	1,863	98	5.95	254	0.0056
3/26-27	M	1,980	0.45	0	699	1,130	1.67	6,140	2.52	840	2,670	399	20.4	255	0
4/26	N	643	0.055	0	313	403	0.35	2,450	0.90	553	1,195	141	9.6	100	0.0113
10/18-19	1	2,760	0.22	0.54	1,240	1,460	3.25	12,500	37.9	2,000	4,760	758	179	395	0.022
11/3	3	1,874	0.208	0.208	1,040	1,250	0.104	16,700	14.6	2,080	3,960	1,150	104	333	0.021
11/16-17	4	753	0.036	0.179	316	316	0	5,020	7.89	431	1,180	205	29.1	96.9	0.007
11/22-25	5	2,730	0.065	0.195	973	1,170	0.065	4,220	3.89	1,300	4,020	325	28.6	389	0.006
12/19-20	6												22.3		
12/23-25	7	7,250	1.77	0.35	4,800	4,740	2.50	15,700	6.26	4,930	12,000	172	37.5	77.0	0.012
12/30-31	8	2,730	0.13	0.195	909	1,230	2.73	4,090	17.5	1,170	3,900	500	31.8	396	0.006
1/8-17/80	9	12,100	1.80	1.90	3,860	4,780		19,300	4.57	3,900	16,500	1,680	35.8	1,580	0.06
2/14-24	10	42,800	3.66	11.3	17,600	18,900	1.18	50,400	28.6	28,600	70,300	530	286	6,800	0.75
2/27-28	11	386	0.26	0.44	184	486	0	7,300	3.05	584	950	783	18.3	127	0.15
3/2-4	12			0.037		424	0.03	2,950	0.90			262	12.2		
3/5-6	13	6,030	0.40	0.11	1,670	2,180	0.27	8,000	2.77	1,650	7,810	949	15.6	861	0.13
3/25	14												1.80		
4/4-5	15							7,590					13.7		
4/20-21	16												11.3		
4/22	17												3.75		

TABLE D-3. STREET SURFACE LOADS, WASH-OFFS AND URBAN RUN-OFF YIELDS FOR MONITORED STORMS

	STORM CODE:								
	4	5	6	7	8	9	10	11	12 & 13
TOTAL P:									
Before storm street (lbs)	7	6	14	9	9	13	7	7	4
After storm street (lbs)	6	4	8	6	9	8	5	3	7
△ street (lbs)	1	2	6	3		6	2	4	-2
Run-off yield (lbs)	11	14	-	164	16	215	389	11	-
Before/after ratio	1.1	1.7	1.8	1.5	1.0	1.7	1.3	2.5	0.6
Before/yield ratio	0.62	0.42	-	0.06	0.55	0.06	0.02	0.71	-
△ street/yield ratio	0.07	0.17	-	0.02		0.03	0.004	0.42	-
O-PO4:									
Before storm street (lbs)	0.3	0.3	0.7	0.4	0.4	0.6	0.3	0.3	0.3
After storm street (lbs)	0.2	0.1	0.3	0.3	0.4	0.4	0.2	0.1	0.3
△ street (lbs)	0.04	0.15	0.3	0.08	0.03	0.3	0.07	0.2	-0.04
Run-off yield (lbs)	9	14	-	392	9.7	313	466	39	-
Before/after ratio	1.2	2.1	2.0	1.3	1.1	1.8	1.3	2.5	0.9
Before/yield ratio	0.03	0.02	-	0.001	0.04	0.002	0.001	0.009	-
△ street/yield ratio	0.004	0.01	-	0.0002	0.003	0.001	0.0002	0.005	-
ARSENIC:									
Before storm street (lbs)	0.17	0.20	0.33	0.22	0.25	0.32	0.15	0.17	0.14
After storm street (lbs)	0.13	0.08	0.13	0.12	0.12	0.16	0.09	0.05	0.13
△ street (lbs)	0.04	0.12	0.20	0.10	0.13	0.17	0.06	0.12	0.01
Run-off yield (lbs)	0.04	0.07	-	1.8	0.13	1.8	3.7	0.26	-
Before/after ratio	1.3	2.4	2.5	1.8	2.1	2.0	1.6	3.5	1.1
Before/yield ratio	4.7	3.1	-	0.12	1.9	0.18	0.04	0.65	-
△ street/yield ratio	1.0	1.8	-	0.06	0.97	0.09	0.02	0.47	-
COPPER:									
Before storm street (lbs)	1.0	1.1	3.0	2.1	1.8	2.8	1.6	1.8	1.3
After storm street (lbs)	0.7	0.5	1.7	1.4	1.9	1.6	1.1	0.7	1.5
△ street (lbs)	0.3	0.6	1.3	0.7	-0.08	1.2	0.5	1.2	-0.2
Run-off yield (lbs)	8	3.9	-	6.3	18	4.6	29	3.1	3.7
Before/after ratio	1.5	2.3	1.8	1.5	0.9	1.8	1.5	2.8	0.9
Before/yield ratio	0.13	0.28	-	0.33	0.10	0.61	0.06	0.58	0.35
△ street/yield ratio	0.04	0.16	-	0.11	-0.004	0.27	0.02	0.37	-0.06

△ street - before storm street loading minus the after storm street loading .

TABLE E-9. MONTHLY PORTION OF ANNUAL BASEFLOW YIELD (%)

Month	Flow	Total Solids	COD	TKN	P	OPU$_4$	As	Cr	Cu	Pb	Zn
October	2%	2%	3%	2%	<1%	2%	3%	17%	<1%	<1%	2%
November	2	2	2	12	6	12	3	<1	<1	<1	3
December	7	7	6	28	29	30	8	5	<1	1	8
January	22	18	17	12	15	12	20	11	31	29	19
February	24	22	19	13	17	15	23	13	36	25	21
March	18	16	16	18	18	16	18	2	23	31	25
April	6	7	7	4	3	8	10	<1	10	14	12
May	5	6	5	3	6	3	2	<1	<1	<1	<1
June*	4	4	6	3	<1	0.5	4	13	<1	<1	2
July *	4	4	6	3	<1	0.5	4	13	<1	<1	2
August*	4	4	6	3	<1	0.5	4	13	<1	<1	2
September*	4	4	6	3	<1	0.5	4	13	<1	<1	2
Annual (lbs)	61 acre-ft	180,000	6000	150	30	120	0.4	0.06	3	6	10
Annual (lbs/acre/yr)	0.8 inches	200	6.5	0.2	0.04	0.13	0.0005	0.00007	0.003	0.0065	0.014

*June, July, August and September show average conditions for all four months combined.

TABLE E-10. MONTHLY PORTION OF ANNUAL STORM YIELD AND AVERAGE PER STORM PORTION OF ANNUAL YIELD

Month	Total Solids % in month	Total Solids % per storm	Lead % in month	Lead % per storm	Zinc % in month	Zinc % per storm	Arsenic % in month	Arsenic % per storm	Copper % in month	Copper % per storm
Oct.	7	4	18	9	18	9	9	5	24	12
Nov.	10	3	16	5	15	5	4	1	17	6
Dec.	8	3	10	4	12	5	10	4	16	6
Jan.	28	6	10	2	15	3	25	6	8	2
Feb.	37	11	37	11	30	9	30	9	27	8
Mar.	7	1	5	1	5	1	4	1	4	1
Apr.	3	<1	4	1	5	1	18	5	4	1
May	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
June	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
July	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aug.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sep.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Month	Chromium % in month	Chromium % per storm	COD % in month	COD % per storm	Phosphorus % in month	Phosphorus % per storm	Ortho OPO_4 % in month	Ortho OPO_4 % per storm	TKN % in month	TKN % per storm
Oct.	14	7	9	5	12	6	14	7	16	8
Nov.	8	3	13	4	7	2	2	1	10	5
Dec.	27	11	11	4	12	5	13	5	5	2
Jan.	7	2	22	5	31	7	31	7	25	6
Feb.	30	9	33	9	33	9	26	7	37	11
Mar.	10	2	7	1	4	1	13	3	4	1
Apr.	4	1	5	1	1	<1	1	<1	3	<1
May	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
June	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
July	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aug.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sep.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

TABLE E-11. URBAN BASE FLOW AND STORM RUNOFF ANNUAL YIELDS COMPARED.

Constituent	Annual Urban Base Flow Total (lbs)	Annual Urban Base Flow Total (lbs/acre/yr)	Percentage of Base-Flow From Urban Area only (%)	Annual Urban Storm Runoff Total (lbs/acre/yr)	Total Urban Runoff and Urban Base Flow (lbs/acre/yr)	Percentage of Total Urban Yield Due to Runoff Only (%)
Total Alk., as $CaCO_3$	40,000	45	51%	70	120	60%
Non-carbonate hardness, as $CaCO_3$	46,000	50	75	30	80	40
Total hardness, as $CaCO_3$	86,000	95	61	100	200	50
Calcium, diss.	16,000	20	57	30	50	60
Magnesium, diss.	11,000	10	65	10	20	50
Potassium, diss.	560	0.6	68	3	4	75
Sodium, diss.	25,000	30	71	20	50	40
Chloride, diss.	47,000	50	84	25	75	30
Sulfate, diss.	32,000	35	58	30	70	40
Total Solids	180,000	200	67	600	800	75
Filterable Solids (TDS)	170,000	190	66	200	400	50
Non-filterable Solids (SS)	1,300	1.4	72	300	300	100
Volatile Non-filterable Solids (VSS)	130	0.14	17	70	70	100
COD	6,000	6.5	65	150	160	90
Total Nitrogen	610	0.7	67	5	6	80
Organic Nitrogen	120	0.1	44	5	5	100
Total Kjeldahl Nitrogen	150	0.2	45	3.5	3.7	95
Ammonia, as N	50	0.05	84	0.2	0.3	70
Nitrites plus Nitrates, as N	440	0.5	77	3	3	100
Total Phosphorus	34	0.04	45	1	1	100
Dissolved Orth-Phosphates as PO_4	120	0.1	71	2	2	100
Arsenic	0.4	0.0005	84	0.01	0.01	100
Cadmium	0.07	0.00008	67	0.01	0.01	100
Chromium	0.06	0.00007	49	0.014	0.014	100
Copper	3	0.003	70	0.1	0.1	100
Iron	54	0.06	21	7	7	100
Lead	6	0.0065	45	0.6	0.6	100
Mercury	0.2	0.0002	59	0.001	0.001	100
Nickel	0	0	-	0.05	0.05	100
Zinc	10	0.014	65	0.5	0.5	100
Flow	61 Acre-ft.	0.8 Inches	53	7.5 Inches	8.3 Inches	90

TABLE E-12. PERCENT OF OBSERVED BASEFLOW CONCENTRATIONS THAT EXCEEDED WATER QUALITY CRITERIA (Five Observations total).*

Constituents:	Irrigation Seaview	Irrigation Knox	Livestock and Wildlife Seaview	Livestock and Wildlife Knox	Industrial Seaview	Industrial Knox	Aquatic Life Seaview	Aquatic Life Knox	Marine Life Seaview	Marine Life Knox	Recreation Uses Seaview	Recreation Uses Knox	Freshwater Public Supplies Seaview	Freshwater Public Supplies Knox
Chloride	*													
Sulfate														
Filterable solids (TDS)	0-80%	0-100%			0-100%	0-100%								
Non-filterable solids (SS)							0	0						
Ammonia							0	0						
Nitrites plus Nitrates			0	0									0	0
Ortho-phosphates									80%	100%	40%	75%		
Arsenic	0	0											0	0
Cadmium	0	0	0	0			0	0	0	0			0	0
Chromium	0	0	0	0			0	0	0	0			0	0
Copper	0-20%	0-20%	0	0			0	0	0	0			0	0
Iron							80%	20%					100%	40%
Lead	0	0	20%	0			0	0					20%	20%
Mercury			20%	20%			100%	80%	100%	80%			0	20%
Nickel							0	0	0	0				
Zinc			0	0			100%	100%	20%	0			0	0
pH	0	0	0	0			0	0	0	0	0	0		
temperature							20%	0			0	0		

*blanks signify that no numeric criteria is available for comparison.

TABLE E-13. PERCENT OF OBSERVED STORM FLOW CONCENTRATIONS THAT EXCEEDED WATER QUALITY CRITERIA (about 35 total observations).

Constituents:	Irrigation Seaview	Irrigation Knox	Livestock & Wildlife Seaview	Livestock & Wildlife Knox	Industrial Seaview	Industrial Knox	Aquatic Life Seaview	Aquatic Life Knox	Marine Life Seaview	Marine Life Knox	Recreation Uses Seaview	Recreation Uses Knox	Freshwater Public Supplies Seaview	Freshwater Public Supplies Knox
Chloride	*												0	0
Sulfate													0	0
Filterable Solids (TDS)	0	0 - 14%			0 - 100%	0 - 29%								
Non-filterable solids (SS)							100%	100%						
Ammonia							0	0						
Nitrites plus Nitrates			0	0									0	0
Ortho-phosphates									100%	100%	64%	65%		
Arsenic	0	0											0	0
Cadmium	0 - 7%	0 - 15%	0	0			7%	15%	13%	25%			7%	15%
Chromium	0	0	0	0			0	0	0	0			7%	5%
Copper	0 - 100%	0 - 100%	0	0			7%	20%	67%	45%			0	0
Iron							100%	100%					100%	100%
Lead	0	0	44%	96%			19%	88%					56%	100%
Mercury			14%	11%			85%	95%	85%	84%			14%	5%
Nickel							100%	50%	100%	50%				
Zinc			0	0			100%	100%	80%	97%			0	0
pH	0	0	0	0			3%	2%	3%	2%	0	0	0	0
Temperature							0	0			0	0		

*Blanks signify that no numeric criteria is available for comparison.

TABLE E-14. ALL CASTRO VALLEY CREEK STORM PERIODS (1979 and 1980 WATER YEARS)

Begin (Knox Time) date	Begin (Knox Time) time	End (Knox Time) date	End (Knox Time) time	Monitored Rain Code	Rain Causing Runoff (inches)	Monitored Creek Flows (acre-feet) Urban	Monitored Creek Flows (acre-feet) Seaview	Monitored Creek Flows (acre-feet) Knox
11/12/78	0000	11/14/78	0000		0.27	1.2	0	1.2
11/19	0000	11/22	1000		1.92	28.9	0.3	29.2
12/1	0100	12/1	0800		0.36	5.3	0.01	5.3
12/17	0800	12/17	1600	A	0.39	3.7	0.05	3.7
12/18	0300	12/18	1900		0.06	1.4	0	1.4
1/3/79	1300	1/3/79	2200		0.10	0.9	0.04	0.9
1/7	1800	1/8	0000	B	0.34	10.5	0.04	10.5
1/8	1200	1/8	1500	C*	1.24	43.5	0.7	44.2
1/9	0500	1/9	1300		0.18	4.4	0.2	4.6
1/10	2000	1/11	2200	D)	2.58	93.2	1.7	94.9
1/14	0300	1/14	2300	E*)	1.43)	66.6	(6.8	52.8
1/15	0200	1/15	1400		0.28)		(	20.6
1/17	1500	1/17	2200		0.24	5.9	0.2	6.1
2/13	0600	2/14	0900	F*	1.20	28.5	0.9	29.4
2/15	2300	2/16	1400	G*)	0.50	14.6	0.6	15.2
2/18	0600	2/21	1100	H + I)	1.66	55.1	13.1	68.2
2/22	0600	2/22	2000	J)	0.64	45.5	12.7	58.2
2/23	0100	2/24	0000		0.18	4.7	6.1	10.8
2/25	2000	2/26	1000		0.07	2.6	2.6	5.2
2/28	1500	3/1	0000	K*	0.58	6.9	1.8	8.7
3/15	1200	3/17	1500	L*	0.75	9.5	1.5	11.0
3/26	0800	3/28	2300	M*	1.98	35.0	13.6	48.6
4/16	1300	4/16	2300		0.05	1.0	0.3	0.9
4/17	0100	4/17	0600		0.04			0.4
4/23	0400	4/24	0000		0.11	0.7	0.3	1.0
4/26	0500	4/26	2000	N*	0.37	6.8	0.3	7.1
5/6	0000	5/7	1300		0.05	1.9	0.5	2.4
10/18	2100	10/20	0200	1*	0.99	19.8	0.07	19.9
10/25	0300	10/25	1900		1.68	52.3	0.6	52.9
11/3	0800	11/3	2200	3*	0.56	33.0	0.4	33.4
11/16	1600	11/17	0400	4*	0.83	17.1	0.09	17.2
11/22	1400	11/25	2200	5*	0.73	23.7	0.2	23.9
12/19	0600	12/20	1900	6*	0.57	7.4	0.1	7.5
12/23	0800	12/26	1200	7*	3.52	140.4	13.3	153.7
12/30	0100	12/31	2200	8*	0.62	23.6	0.3	23.9
1/8/80	1900	1/18/80	1200	9*	4.12	110.5	56.9	167.4
2/14	0200	2/24	0700	10*	5.94	343.1	91.8	434.9
2/25	1200	2/28	1300	11*	0.74	22.5	7.0	29.5
3/2	0100	3/3	2300	12*)	1.27	13.1	4.1	17.2
3/4	2300	3/7	1100	13)		29.4	9.3	38.7
3/25	0500	3/26	1400	14*)	0.19	2.0	0.8	2.8
4/3	1500	4/6	1500	15*	1.06	28.9	1.9	30.8
4/20	1200	4/21	2000	16*)	0.39	6.9	0	6.9
4/22	1400	4/22	2200	17)		3.5	0	3.5
			TOTALS		40.78	1356.0	251.0	1607.0

* Complete storm data sets

TABLE E-15. NECESSARY CONTROL FOR BASE FLOW CONCENTRATIONS IN CASTRO VALLEY CREEK TO MEET CRITERIA (% removal)

Constituents	Level of Observ.*	Value (mg/l) Seaview/ Knox	Irrigation		Livestock and Wildlife		Industrial		Aquatic Life		Marine Life		Recreation Uses		Freshwater Supplies	
			Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox
Filterable Solids	Max.	1300/1100	62% **	55% **			88% **	86% **								
	Avg.	840/950	40 **	47 **			82 **	84 **								
	Min.	490/680		26 **			69 **	78 **								
Ortho-phosphates	Max.	2.9/2.4									100%	100%	90%	88%		
	Avg.	1.6/1.2									100	100	81	75		
	Min.	0/0.3										100				
Copper	Max.	0.02/0.023		13 **												
Iron	Max.	5.6/1.4							82%	29%					95%	79%
	Avg.	2.8/0.56							64						89	46
	Min.	0.8/0.17													63	
Lead	Max.	0.15/0.076			33%										67	34
Mercury	Max.	0.0017/ 0.0023			41	57%			100	100	94	96				13
	Avg.	0.0005/ 0.0007							90	93	80	86				
	Min.	0.0001/0							50							
Zinc	Max.	0.1/0.09							90	89						
	Avg.	0.06/0.07							83	86						
	Min.	0.03/0.03							67	67						

*If the maximum concentrations observed meet the criteria, then all observed concentrations will meet the criteria. Similarly, if only the average observed concentrations meet the criteria, then higher concentrations may not meet the criteria. The control necessary for the minimum observed concentrations to meet the criteria is the minimum control that would produce any "results". If no values are shown for average or minimum concentrations, only the "maximum" values (greater than the average value) require control. If no values, or constituents are shown, then they do not require control, based on the available numeric criteria. Some narrative criteria may still be exceeded, based on local conditions.

**These removals are necessary to meet the most severe criteria in this class. Many less critical uses in this class may be unaffected by current water quality, or by less demanding controls.

TABLE E-16. NECESSARY CONTROL FOR STORM WATER CONCENTRATION IN CASTRO VALLEY CREEK TO MEET CRITERIA (% removal)

Constituents	Level of Observ.*	Value (mg/l)		Irrigation		Livestock and Wildlife		Industrial		Aquatic Life		Marine Life		Recreation Uses		Freshwater Supplies	
		Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox
Filterable Solids	Max.	500	244					70%**	39%**								
	Avg.	300	125					50 **									
	Min.	176	73					15 **									
Non-filterable solids	Max.	1220	600							93%	87%						
	Avg.	640	250							88	68						
	Min.	94	40							15							
Ortho-Phosphates	Max.	0.8	0.95									100%	100%	63%	68%		
	Avg.	0.4	0.46									100	100	23	35		
	Min.	0.03	0.06									99	100				
Cadmium	Max.	0.023	0.012	57%**	17%**					57	17					57%	17%
Chromium	Max.	0.06	0.06													17	17
Copper	Max.	0.1	0.7	80 **	97 **		29%				86	50	93				
	Avg.	0.056	0.1	64 **	80 **							11	50				
	Min.	0.030	0.021	33 **	5 **												
Iron	Max.	50	21							98	95					99	99
	Avg.	23	9.3							96	89					99	97
	Min.	1.9	5.0							47	80					84	94
Lead	Max.	0.6	3.3			83%	97			67	94					92	95
	Avg.	0.11	0.49			13	80				59					56	90
	Min.	0	0.097														50
Mercury	Max.	0.0026	0.0025			62	60			98	98	96	96			23	20
	Avg.	0.0006	0.0004							92	88	83	75				
	Min.	0	0														
Nickel	Max.	0.1	0.1							99	99	99	99				
	Avg.	0.069	0.037							86	73	86	73				
Zinc	Max.	0.50	2.2							98	100	80	95				
	Avg.	0.18	0.31							94	97	44	68				
	Min.	0.06	0.093							83	89						

*If the maximum concentrations observed meet the criteria, then all observed concentrations will meet the criteria. Similarly, if only the average observed concentrations meet the criteria, then higher concentrations may not meet the criteria. The control necessary for the minimum observed concentrations to meet the criteria is the minimum control that would produce any "results". If no values are shown for average or minimum concentrations, only the "maximum" values (greater than the average value) require control. If no values, or constituents are shown, then they do not require control, based on the available numeric criteria. Some narrative criteria may still be exceeded, based on local conditions.

**These removals are necessary to meet the most severe criteria in this class. Many less critical uses in this class may be unaffected by current water quality, or by less demanding controls.

TABLE E-17. SEAVIEW STATION WATER QUALITY FOR MONITORED STORMS
(Castro Valley Creek) (mg/l unless otherwise noted).

Storm Date:	Total Alk. as $CaCO_3$	As, (ug/l)	Cd (ug/l)	Ca (diss)	Cl (diss)	Cr (ug/l)	COD	Cu (ug/l)	Non-carbonate Hardness	Total Hardness	Fe (μg/l)	Pb (μg/l)	Mg (diss)	Hg (μg/l)	Ni (μg/l)	NH_4 as N
1/8/79							193									0.35
1/10-11																
1/14																
2/13-14	95	6	0	29	29	30	140	60	31	130	26,000	0	13	0.2	70	0.22
2/15-16	120	4	0	44	110	10	63	40	64	180	12,000	0	18	0.1	50	0.24
2/18-19	110	6	0	34	31	30	110	50	33	140	27,000	0	14	0.1	50	0.20
2/20-21	66	6	0	24	19	40	170	70	32	98	37,000	0	9.2	0.1	100	0.18
2/22	62	7	0	24	15	60	150	70	32	94	36,000	0	8.3	0.2	100	0.12
2/28	92	4	0	31	28	20	74	50	39	130	14,000	0	13	0	100	0.19
3/15-17	200	2	0	66	44	10	50	40	68	270	5,000	0	25	0.1	0	0.09
3/26-27	120	4	0	40	25	20	92	30	46	170	17,000	100	16	0	0	0.11
4/26	180	4	0	58	44	40	62	60	68	250	12,000	0	25	0.3	0	0.07
12/23-25	89	9	2	29	19	0	120	70	37	130	50,000	83	13	0.8	100	0.16
1/8-17/ 80	110	6	23	28	22	10	140	100	13	120	48,000	210	13	0.2	100	0.25
2/14-24	89	9	2	29	19	0	120	70	37	130	50,000	83	13	0.8	100	0.16
2/27-28	160	3	6	49	29	0	78	50	49	210	26,000	300	21	2.6	100	0.04
3/2-4			1		37	2	33	44			7,300	160				0.03
3/5-6	140	5	4	42	26	10	75	40	47	190	1,900	170	20	2.2	100	0.11
3/25												100				
4/4-5							150					600				

Storm Date:	Total N	Total Organic N	TKN as N	NO_2 + NO_3 as N	Diss. Ortho PO_4 as PO_4	Total P	K (diss)	TDS	Total Solids	Suspended Solids	Volatile Suspended Solids	Na (diss)	SO_4 (diss)	Zn (μg/l)
1/8/79			6.65			1.86		495	1,715	1,220				496
1/10-11									1,087					139
1/14									402					72.4
2/13-14	3.4	1.8	2.0	1.4	0.80	0.53	3.7	253	813	560	86	27	49	150
2/15-16	7.6	2.5	2.7	4.9	0.74	0.41	4.4	433	695	228	52	79	68	90
2/18-19	8.1	6.5	6.8	1.3	0.58	0.45	3.5	261	893	580	100	28	50	150
2/20-21	15	14	14	1.3	0.64	1.9	3.2	190	1,170	818	138	20	35	210
2/22	6.2	4.8	4.9	1.3	0.43	0.73	2.6	176	1,180	1,010	136	13	30	200
2/28	3.6	2.4	2.6	0.95	0.40	0.27	3.1	223	613	378	26	23	44	120
3/15-17	2.0	1.0	1.1	0.90	0.37	0.26	2.4	415	525	110	31	43	100	60
3/26-27	3.8	2.6	2.7	1.1	0.52	0.57	2.7	276	771	440	80	28	59	130
4/26	2.5	1.6	1.7	0.81	0.03	0.37	2.2	409	680	304	74	41	87	110
12/23-25	5.4	3.9	4.1	1.5	0.10	0.57	2.6	231	1,291	1,060	136	21	46	200
1/8-17/ 80	7.3	5.2	5.4	1.9	0.15	0.70	3.2	228	1,212	984	118	24	44	300
2/14-24	5.4	3.7	3.9	1.5	0.31	0.57	2.6	211	1,431	1,200	136	21	46	200
2/27-28	3.6	2.3	2.3	1.3	0.15	0.08	2.6	344	1,028	684	80	34	75	190
3/2-4	2.1	0.82	0.85	1.2		0.11		391	485	94				80
3/5-6	3.3	2.2	2.3	0.99	0.18	0.38	1.9	300	848	536	108	30	64	150
3/25									405					120
4/4-5									982					500

TABLE E-18. BASE FLOW CONCENTRATIONS MONITORED

	Seaview Base Flow Concentrations						Knox Base Flow Concentrations					
Constituent, mg/l, Unless Noted	Oct. (1)	Nov. & Dec. (2)	Jan. & Feb. (3)	Mar. & April (4)	May (5)	June - Sept. (6)	Oct. (1)	Nov. & Dec. (2)	Jan. & Feb. (3)	Mar. & April (4)	May (5)	June - Sept. (6)
Total alk., as $CaCO_3$	320	360	250	250	320	320	260	300	290	230	210	250
Non-carbonate hardness, as $CaCO_3$	260	340	71	67	140	200	300	300	160	140	340	320
Total Hardness as $CaCO_3$	580	750	320	320	460	520	560	600	450	370	550	550
Calcium, diss.	130	160	74	74	100	115	110	120	94	74	95	100
Magnesium, diss.	63	85	33	32	52	58	70	74	52	44	76	73
Potassium, diss.	1.1	1.5	2.8	1.1	3.4	2.3	4.5	4.5	2.3	2.0	3.5	4.0
Sodium, diss.	120	160	57	52	89	105	150	170	100	92	160	160
Chloride, diss.	130	170	55	46	95	115	300	290	150	130	300	300
Sulfate, diss.	340	450	120	120	200	270	240	230	160	150	260	250
Total Solids	1,110	1,360	537	507	846	980	1,220	1,190	827	689	1,170	1,200
Filterable Solids (TDS)	1,050	1,310	531	493	797	920	1,060	1,130	798	678	1,090	1,080
Non-filterable Solids (SS)	11	42	15	0	0	5	1.0	0	11	5	0	1
Volatile Non-filterable Solids (VSS)	8	0	14	0	11	10	1.0	0	4	1	5	3
COD	33	27	34	14	28	30	54	32	30	21	34	44
Total Nitrogen	1.8	1.6	1.5	2.6	1.3	1.6	1.7	5.8	3.5	2.6	1.5	1.6
Organic Nitrogen	1.1	0.95	0.64	1.2	0.81	1.0	1.0	0.8	0.6	1.2	0.7	0.8
Total Kjeldahl Nitrogen	1.6	1.4	0.81	1.4	1.1	1.4	1.1	3.2	0.6	1.2	0.8	1.0
Ammonia, as N	0.53	0.45	0.17	0.06	0.29	0.41	0.1	2.4	0.02	0	0.05	0.08
Nitrites plus Nitrates, as N	0.18	0.15	0.85	1.2	0.18	0.18	0.6	2.6	2.9	1.4	0.7	0.7
Total Phosphorus	2.8	2.4	0.09	0.11	0.03	1.4	0.47	1.2	0.13	-	0.17	0.32
Dissolved Ortho-Phosphates, as PO_4	2.9	1.9	0.07	0.09	0	1.4	1.1	2.9	0.31	-	0.28	0.7
Arsenic (ug/l)	2	3	1	0	1	1	3	3	2	1	1	2
Cadmium (ug/l)	0	0	1	0	0	0	0	0	1	0	0	0
Chromium (ug/l)	10	7	0	3	10	10	20	3	1	2	0	10
Copper (ug/l)	0	1	17	8	20	10	0	0	23	13	0	0
Iron (ug/l)	3,400	5,600	3,100	1,100	800	2,100	270	230	1,400	750	170	230
Lead (ug/l)	0	13	150	29	0	0	0	8	76	41	0	0
Mercury (ug/l)	0.2	0.1	0.3	1.7	0.1	0.2	0.6	0.1	0	2.3	0.3	0.5
Nickel (ug/l)	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (ug/l)	100	70	70	30	50	75	90	80	70	60	30	60

(1) Based on 10/10-11/79 monitoring
(2) Based on 11/30-12/1/79 monitoring
(3) Based on 1/24-25/80 monitoring
(4) Based on 3/28/80 monitoring
(5) Based on 5/25-26/79 monitoring
(6) Based on average of 5/25-26 and 10/10-11 monitoring

TABLE E-19. CASTRO VALLEY CREEK OBSERVED BASE FLOW RELATIVE CONCENTRATIONS (mg constituent/kg total solids)

Constituent	Seaview Station				Knox Station			
	Minimum	Maximum	Average	Number of Observation	Minimum	Maximum	Average	Number of Observation
Total alk., as $CaCO_3$	270,000	490,000	380,000	5	180,000	350,000	270,000	5
Non-carbonate hardness, as $CaCO_3$	130,000	290,000	190,000	5	190,000	290,000	240,000	5
Total hardness, as $CaCO_3$	500,000	630,000	570,000	5	460,000	540,000	500,000	5
Calcium, diss.	120,000	150,000	130,000	5	81,000	110,000	100,000	5
Magnesium, diss.	57,000	63,000	61,000	5	57,000	65,000	62,000	5
Potassium, diss.	1,000	5,200	2,700	5	2,800	3,800	3,200	5
Sodium, diss.	100,000	120,000	110,000	5	120,000	140,000	130,000	5
Chloride, diss.	91,000	130,000	110,000	5	180,000	260,000	220,000	5
Sulfate, diss.	220,000	330,000	270,000	5	190,000	220,000	200,000	5
Filterable Solids (TDS)	940,000	990,000	960,000	5	870,000	980,000	940,000	5
Non-filterable Solids (SS)	0	31,000	14,000	5	0	13,000	4,300	5
Volatile, Non-filterable Solids (VSS)	0	26,000	92,000	5	0	4,800	2,300	5
COD	20,000	63,000	36,000	5	27,000	44,000	33,000	5
Total Nitrogen	1,200	5,100	2,400	5	1,300	4,900	3,100	5
Organic Nitrogen	700	2,400	1,200	5	620	1,700	910	5
Total Kjeldahl Nitrogen	1,000	2,800	1,600	5	660	1,700	1,300	5
Ammonia, as N	120	480	320	5	0	2,000	430	5
Nitrites plus Nitrates, as N	110	2,400	890	5	490	3,500	1,800	5
Total Phosphorus	36	2,500	940	5	150	1,000	420	4
Dissolved Ortho-Phosphates, as PO_4	0	2,600	1,300	3	240	2,400	990	4
Arsenic	0	2.2	1.4	5	0.9	2.5	2.0	5
Cadmium	0	1.9	0.4	5	0	1.2	0.2	5
Chromium	0	12	6	5	0	16	4.6	5
Copper	0	24	9	5	0	28	9.3	5
Iron	950	5,800	3,200	5	150	1,700	670	5
Lead	0	280	70	5	0	92	32	5
Mercury	0.07	3.4	0.9	5	0	3.3	0.8	5
Nickel	0	0	0	5	0	0	0	5
Zinc	52	130	78	5	25	87	68	5

TABLE E-20. CASTRO VALLEY CREEK AND URBAN AREA OBSERVED STORM PERIOD RELATIVE CONCENTRATIONS (mg constituent/kg total solids)

	Seaview Station				Knox Station						Urban Area Only					
Constituent	Min.	Max.	Avg.	No. of Observ.	Min.	Max.	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	No. of Observ.	Min.	Max.	Avg.	Std. Dev.	Std. Dev./ Avg. Ratio	N of Observ.
Total alk., as $CaCO_3$	53,000	380,000	130,000	14	36,000	300,000	140,000	66,000	0.5	19	12,000	300,000	140,000	76,000	0.5	19
Non-carbonate hardness, as $CaCO_3$	11,000	130,000	53,000	14	19,000	160,000	73,000	38,000	0.5	19	17,000	180,000	83,000	46,000	0.6	19
Total hardness, as $CaCO_3$	80,000	510,000	200,000	14	73,000	440,000	210,000	100,000	0.5	19	28,000	440,000	220,000	110,000	0.5	19
Calcium, diss.	20,000	130,000	47,000	14	19,000	110,000	52,000	23,000	0.4	19	5,500	110,000	57,000	29,000	0.5	19
Magnesium, diss.	7,000	48,000	19,000	14	5,800	45,000	20,000	11,000	0.6	19	69	44,000	20,000	13,000	0.6	19
Potassium, diss.	1,800	6,300	3,400	14	940	32,000	7,100	-	-	19	2,300	32,000	8,500	6,900	0.8	19
Sodium, diss.	11,000	110,000	39,000	14	9,600	110,000	42,000	-	-	19	6,800	110,000	46,000	26,000	0.6	19
Chloride, diss.	13,000	160,000	44,000	15	15,000	130,000	54,000	27,000	0.5	20	14,000	130,000	62,000	32,000	0.5	20
Sulfate, diss.	25,000	190,000	70,000	14	24,000	160,000	76,000	-	-	20	9,700	160,000	83,000	44,000	0.5	19
Filterable Solids (TDS)	150,000	810,000	370,000	16	34,000	860,000	390,000	-	-	21	83,000	860,000	420,000	220,000	0.5	20
Non-filterable Solids (SS)	190,000	860,000	610,000	16	2,300	880,000	560,000	-	-	22	40,000	1,300,000	590,000	300,000	0.5	20
Volatile Non-filterable Solids (VSS)	42,000	130,000	96,000	14	0	330,000	134,000	-	-	9	19,000	810,000	180,000	180,000	1.0	16
COD	8,800	170,000	100,000	17	22,000	730,000	270,000	160,000	0.6	24	150,000	1,000,000	400,000	210,000	0.5	22
Total Nitrogen	430	13,000	5,500	15	940	19,000	9,600	-	-	19	3,700	20,000	11,000	4,900	0.4	19
Organic Nitrogen	1,700	12,000	3,800	15	1,000	36,000	7,500	-	-	22	0	56,000	8,300	12,000	1.5	20
Total Kjeldahl Nitrogen	1,800	12,000	4,200	16	1,600	15,000	6,200	-	-	22	0	15,000	6,000	4,800	0.8	20
Ammonia, as N	62	350	170	16	0.7	790	230	-	-	22	0	920	260	270	1.0	20
Nitrites plus Nitrates, as N	1.6	7,100	1,700	15	1,200	8,400	3,600	-	-	19	1,400	15,000	4,900	3,300	0.7	19
Total Phosphorus	76	1,600	590	16	220	2,000	1,200	540	0.4	21	920	3,400	1,500	750	0.5	20
Dissolved Ortho-phosphates, as PO_4	44	1,100	460	14	570	4,200	1,500	-	-	20	170	8,200	2,200	2,000	0.9	19
Arsenic	2.8	7.4	5.7	14	4.0	36	13	7	0.6	20	4.0	40	17	12	0.7	19
Cadmium	0	19	2.2	15	0	26	7	9	1.3	20	0	52	9	14	1.5	20
Chromium	0	59	22	15	0	190	40	49	1.2	20	0	190	53	54	1.0	18
Copper	39	91	64	15	64	1,400	320	420	1.3	20	36	1,400	340	410	1.2	20
Iron	2,200	40,000	25,000	15	15,000	260,000	37,000	52,000	1.4	20	2,400	52,000	24,000	11,000	0.5	20
Lead	0	610	120	17	17	6,700	1,500	1,600	1.1	25	280	6,800	1,900	1,600	0.8	25
Mercury	0	2.6	0.6	14	0	3.7	1.1	1.1	1.0	19	0	4.5	1.3	1.4	1.0	19
Nickel	0	160	62	16	0	450	100	-	-	18	0	450	130	150	1.2	16
Zinc	110	300	180	19	250	4,500	960	-	-	30	240	4,500	1,200	880	0.8	28

TABLE E-21. RUN-OFF YIELD CALCULATION FOR TOTAL TEST AREA

	Total Solids	Lead	Zinc	Arsenic	Copper	Chromium	COD	Total Phosphorus	Ortho-Phosphate	Total Kjeldahl Nitrogen
Year 1 monitored	355,400	145	207	3.01	22.3	9.89	65,400	347	317	1,310
Year 1 correction	50,700	124	37	4.28	13.8	3.63	33,200	271	1,110	765
Total Year 1 lbs/year	406,000	269	244	7.29	36.1	13.5	99,000	618	1,420	2,080
lbs/acre/year (909 acres)	450	0.30	0.27	0.0080	0.040	0.015	110	0.70	1.6	2.3
Year 2 monitored	606,700	832	572	8.22	130	10.2	154,000	922	1,300	3,030
Year 2 correction	44,500	28	21	4.04	11	1.9	17,100	362	806	1,230
Total Year 2 lbs/yr.	651,000	860	592	12.3	141	12.1	170,000	1,284	2,110	4,260
lbs/acre/year (909 acres)	720	0.95	0.65	0.014	0.16	0.013	190	1.4	2.3	4.7
Two-year average urban runoff yield (lbs/acre/year)	600	0.6	0.5	0.01	0.1	0.014	150	1	2	3.5
Percent of total yield actually monitored	91%	87%	93%	57%	86%	79%	82%	67%	46%	68%

TABLE E-22. KNOX STATION WATER QUALITY FOR MONITORED STORMS
(Castro Valley Creek) (mg/l unless otherwise noted).

Storm Date:	Total Alk. as $CaCO_3$	As (ug/l)	Cd (ug/l)	Ca (diss)	Cl (diss)	Cr (ug/l)	COD	Cu (ug/l)	Non-carbonate Hardness	Total Hardness	Fe (ug/l)	Pb (ug/l)	Mg (diss)	Hg (ug/l)	Ni (ug/l)	NH_4 as N
12/17/78		3					99									0.04
1/7/79							41									0.024
1/8							132									0.09
1/10-11																
1/14																
2/13-14	33	5	0	12	12	10	120	40	16	49	6,800	300	4.5	0.4	10	0.02
2/15-16	34	4	0	14	13	0	46	40	22	56	5,000	100	5.0	0.2	60	0.05
2/18-19	48	4	0	18	20	10	69	40	25	73	5,800	200	6.9	0.2	30	0.05
2/20-21	39	6	0	15	14	10	72	40	22	61	8,500	200	5.7	0.1	0	0.07
2/22	30	6	0	13	9.8	40	96	50	19	49	21,000	300	3.9	0.2	70	0.07
2/28	34	6	0	12	9	20	85	50	13	47	8,000	200	4.1	0.1	100	0.09
3/15-17	58	3	0	21	21	20	80	40	44	100	4,000	200	12	0.2	0	0.02
3/26-27	53	5	0	18	17	20	79	30	21	74	8,500	200	7	0	0	0.03
4/26	42	3	0	19	23	20	130	50	32	74	7,900	500	6.4	0.6	0	0.05
10/18-19	51	4	10	23	27	60	230	700	37	88	14,000	3,300	7.3	0.4	0	0.37
11/3	18	2	2	10	12	1	16	140	20	38	11,000	1,000	3.2	0.2	0	0.08
11/16-17	21	1	5	8.8	8.8	0	140	220	12	33	5,700	810	2.7	0.2	0	0.15
11/22-25	42	1	3	15	18	1	65	60	20	62	5,000	440	6.0	0.1	0	0.11
12/19-20												1,100				
12/23-25	25	5	1	14	13	6	48	21	15	40	4,700	97	1.3	0.1	0	0.12
12/30-31	42	2	3	14	19	42	63	270	18	60	7,700	490	6.1	0.1	100	0.04
1/8-17/80	64	6	12	18	18	0	90	44	13	77	20,000	150	7.9	0.2	100	0.16
2/14-24	55	5	10	21	20	1	68	39	32	87	11,000	260	8.5	0.8	0	0.13
2/27-28	43	4	7	14	13	0	110	50	19	62	16,000	300	6.6	2.5	100	0.06
3/2-4			1		18	1	71	30			5,600	300				
3/5-6	91	5	2	26	27	5	78	36	27	120	9,500	190	13	1.8	100	0.06
3/25												400				
4/4-5							100					200				
4/20-21												600				
4/22/80												400				

TABLE E-22. KNOX STATION WATER QUALITY FOR MONITORED STORMS
(Castro Valley Creek) (mg/l unless otherwise noted).

Storm Date:	Total N	Total Organic N	TKN	$NO_2 + NO_3$ as N	Diss. Ortho PO_4 as PO_4	Total P	K (diss)	TDS	Total Solids	Suspended Solids	Volatile Suspended Solids	Na (diss)	SO_4 (diss)	Zn (ug/l)
12/17/78		1.4	1.4			0.41			232				19	146
1/7/79		0.75	0.75		0.22			107	132	24.6				93.4
1/8		3.0	3.10			0.85		244	734	490				462
1/10-11									276					124
1/14									173					107.8
2/13-14	2.4	1.4	1.4	0.97	0.49	0.39	1.3	100	140	22	0	10	17	160
2/15-16	4.0	3.1	3.1	0.93	0.43	0.24	1.1	94	223	103	31	10	21	110
2/18-19	2.4	1.3	1.3	1.1	0.64	0.27	1.2	135	279	133	39	16	29	150
2/20-21	3.1	1.7	1.8	1.3	0.86	0.56	1.6	113	329	207	46	12	22	160
2/22	4.1	2.8	2.9	1.2	0.83	0.55	1.5	95	670	466	96	6.4	16	210
2/28	2.4	1.5	1.6	0.77	0.61	0.29	1.5	78	317	260	16	8.3	15	220
3/15-17	1.6	0.63	0.65	0.90	0.31	0.23	1.5	125	269	144	8	16	37	140
3/26-27	2.7	1.6	1.6	1.1	0.21	0.42	1.8	127	350	286	117	14	25	140
4/26	3.3	2.7	2.7	0.62	0.06	0.36	2.6	130	380	216	74	14	22	250
10/18-19	9.2	7.1	7.5	1.7	0.64	0.81	4.0	165	490	354	98	14	32	2,200
11/3	3.5	2.7	2.8	0.73	0.28	0.56	16	79	495	396	66	7.7	16	740
11/16-17	2.9	1.6	1.7	1.2	0.25	0.3	1.8	73	192	132	38	6.6	13	340
11/22-25	1.9	1.1	1.2	0.67	0.21	0.22	2.5	121	140	40	32	15	22	250
12/19-20									232					630
12/23-25	2.3	0.23	0.35	1.9	0.95	0.44	1.8	95	226	112	18	9.6	17	148
12/30-31	2.6	1.8	1.8	0.78	0.15	0.25	1.5	115	221	83	22	14	23	300
1/8-17/80	4.9	2.8	3.0	1.9	0.74	0.71	2.4	148	682	534	100	16	27	170
2/14-24	3.5	1.9	2.0	1.5	0.46	0.45	1.7	157	486	298	34	17	34	180
2/27-28	3.5	24	2.5	0.88	0.52	0.15	1.7	117	671	596	80	11	22	250
3/2-4									342					210
3/5-6	2.6	1.4	1.5	1.1	0.34	0.39	1.5	214	527	306	56	24	43	150
3/25									306					300
4/4-5									180					260
4/20-21									517					390
4/22/80									190					210

TABLE E-23. YEAR ONE FIELD MEASUREMENTS

BASE FLOW

Date	Time	PH		Specific Conductance (umhos/cm)		Temperature (°C)	
		Seaview	Knox	Seaview	Knox	Seaview	Knox
1/4/79	0535	-	7.8	-	1044	-	8.5
5/25/79	Composite	7.5	7.7	1153	1193	19	19
Min.		-	7.7	-	1044	-	8.5
Max.		-	7.8	-	1193	-	19
Mean		7.5	7.8	1153	1120	19	14
No. of Observ.		1	2	1	2	1	2

STORM DATA

Date	Time @ Knox	Seaview	Knox	Seaview	Knox	Seaview	Knox
12/17/78	0700	-	7.2	-	111	-	10.5
	0815	-	6.8	-	125	-	10.5
	0910	-	7.0	-	320	-	10.5
	1015	-	7.4	-	459	-	10.5
	1125	-	7.4	-	233	-	11
	1215	-	7.2	-	233	-	11
	1315	-	7.1	-	96	-	11
	1420	-	7.5	-	151	-	11
	1515	-	7.2	-	158	-	11
	1610	-	7.0	-	110	-	11
1/7-8/79	1745	-	7.7	-	133	-	11
	1845	-	7.7	-	127	-	11
	1945	-	7.6	-	108	-	11
	2050	-	7.5	-	136	-	11
	2145	-	7.5	-	178	-	11
	2245	-	7.5	-	203	-	11
	2345	-	7.6	-	178	-	11
1/8/79	0945	-	7.3	-	451	-	10
	1030	-	7.2	-	96	-	11
	1130	-	7.5	-	71	-	10
	1230	-	7.4	-	53	-	11
	1330	7.6	7.2	154	108	10	11
	1430	7.4	7.5	274	169	10	10
	1530	7.3	7.6	343	301	11	11

TABLE E-23. YEAR ONE FIELD MEASUREMENTS (Contd.)

Storm Data (Contd.)

Date	Time @ Knox	PH		Specific Conductance (umhos/cm)		Temperature (°C)	
		Seaview	Knox	Seaview	Knox	Seaview	Knox
1/10-11/79	2130	7.6	8.0	156	84	11	12
	2230	-	7.6	-	114	-	10.5
	2330	7.6	7.5	148	126	11	12
	0030	7.6	7.6	210	173	11	12
	0130	7.6	7.7	233	82	11	11
	0230	7.5	7.7	169	146	11	12
	0330	7.5	7.7	344	221	11	11
	0430	7.5	7.6	571	271	11	11
	0530	7.7	7.5	480	226	11	12
	0630	7.7	7.5	323	223	12	12
	0730	7.7	7.9	418	326	12	13
1/14/79	0230	7.1	7.5	1,140	1,430	10	10.5
	0300	-	7.3	-	370	-	10
	0400	7.1	7.4	376	313	9.5	10
	0500	7.3	7.0	264	92	9	9.5
	0600	7.2	7.2	316	442	9	9
	0700	7.2	7.2	287	145	9	9
	0800	7.2	7.2	1,073	554	9	9
	0900	7.3	7.2	439	247	9.5	9.5
	1020	-	7.4	-	346	-	9.5
2/13-14/79	Composite	7.1	7.3	368	157	14	5
2/15-16/79	Composite	7.0	7.0	822	156	11	13
2/18-19/79	Composite	7.1	6.7	395	223	8	7
2/20/79	Composite	7.0	7.0	180	110	6	6
2/20-21/79	Composite	-	7.1	-	145	-	6
2/22/79	Composite	6.8	6.9	228	130	8.5	9
2/28-3/1/79	Composite	7.4	7.4	210	75	4	4
3/15-17/79	Composite	7.6	7.6	652	269	5	4
3/26-28/79	Composite	7.1	7.3	420	216	9	7
4/26/79	Composite	7.5	6.9	714	226	16	12
Minimum		6.8	6.8	148	53	4	4
Maximum		7.7	8.0	1,140	1,430	16	13
Mean		7.4	7.4	404	221	10	10
No. of Observations		29	54	29	54	29	54

TABLE E-24. YEAR ONE STORM TURBIDITY MEASUREMENTS

		Turbidity (NTU)	
Date	Time	Seaview	Knox
1/7/79	1800	-	29
	1900	-	30
	2000	-	33
	2100	-	16
	2200	-	10
	2300	-	13
1/8/79	1030	-	84
	1130	-	108
	1230	400	156
	1330	320	140
	1430	136	68
1/10/79	2110	-	40
	2210	608	64
	2310	624	64
1/11/79	0010	432	39
	0110	352	36
	0210	312	52
	0310	280	54
	0410	264	58
	0510	200	40
	0610	264	73
	0710	192	68
1/14/79	0400	-	48
	0500	72	38
	0600	116	36
	0700	120	44
	0800	272	42
	0900	240	32
	1000	-	37
2/14/79	0800-0900	432	78
2/16/79	1000	224	46
2/20/79	1900	480	116
2/21/79	1000	-	112
2/22/79	1500	420	204
2/26/79	-	396	68
2/28/79	-	216	112
3/17/79	1400	62	58
3/26/79	1200	228	93
1/18/80	-	160	96
Min.		72	10
Max.		624	204
Mean		290	65
No. of observations		27	39

TABLE E-25. YEAR TWO FIELD MEASUREMENTS

BASE FLOW

DATE	PH		Specific Conductance (umhos/cm)		Temperature (°C)	
	Seaview	Knox	Seaview	Knox	Seaview	Knox
10/11/79	6.5	7.2	1100	1180	22	20
11/30/79	7.5	8.0	1870	1810	19	18
1/24/80	7.3	7.8	790	1180	6	4
3/28/80	8.2	-	730	1110	9	6
Min.	6.5	7.2	730	1110	6	4
Max.	8.2	8.0	1870	1810	22	20
Mean	7.4	7.7	1120	1320	14	12
No. of Observ.	4	3	4	4	4	4

STORM DATA

DATE	PH		Specific Conductance (umhos/cm)		Temperature (°C)	
	Seaview	KNOX	Seaview	Knox	Seaview	Knox
10/18-22/79	-	6.1	-	230	-	8.5
11/3/79	7.8	7.5	380	120	7	14
11/16-17/79	-	7.7	-	100	-	5
11/22-25/79	-	7.8	-	190	-	19
12/22-26/79	-	7.1	-	150	-	8.5
12/30-31/79	-	8.0	-	170	-	15.5
1/8-18/80	6.0	7.2	340	220	11	11
2/14-24/80	6.5	7.4	330	230	10	10
2/25-28/80	7.4	7.5	540	180	8	8
3/2-3/80	7.6	7.6	650	240	6	5
3/4-7/80	7.1	7.0	460	330	5	5
4/3-6/80	8.1	7.0	560	170	19.5	13
Min.	6.0	6.1	330	100	5	5
Max.	8.1	8.0	650	330	19.5	15.5
Mean	7.2	7.3	470	190	9.5	10.2
No. of Obser.	7	12	7	12	7	12

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of DECEMBER 17, 1978
STORM "A"

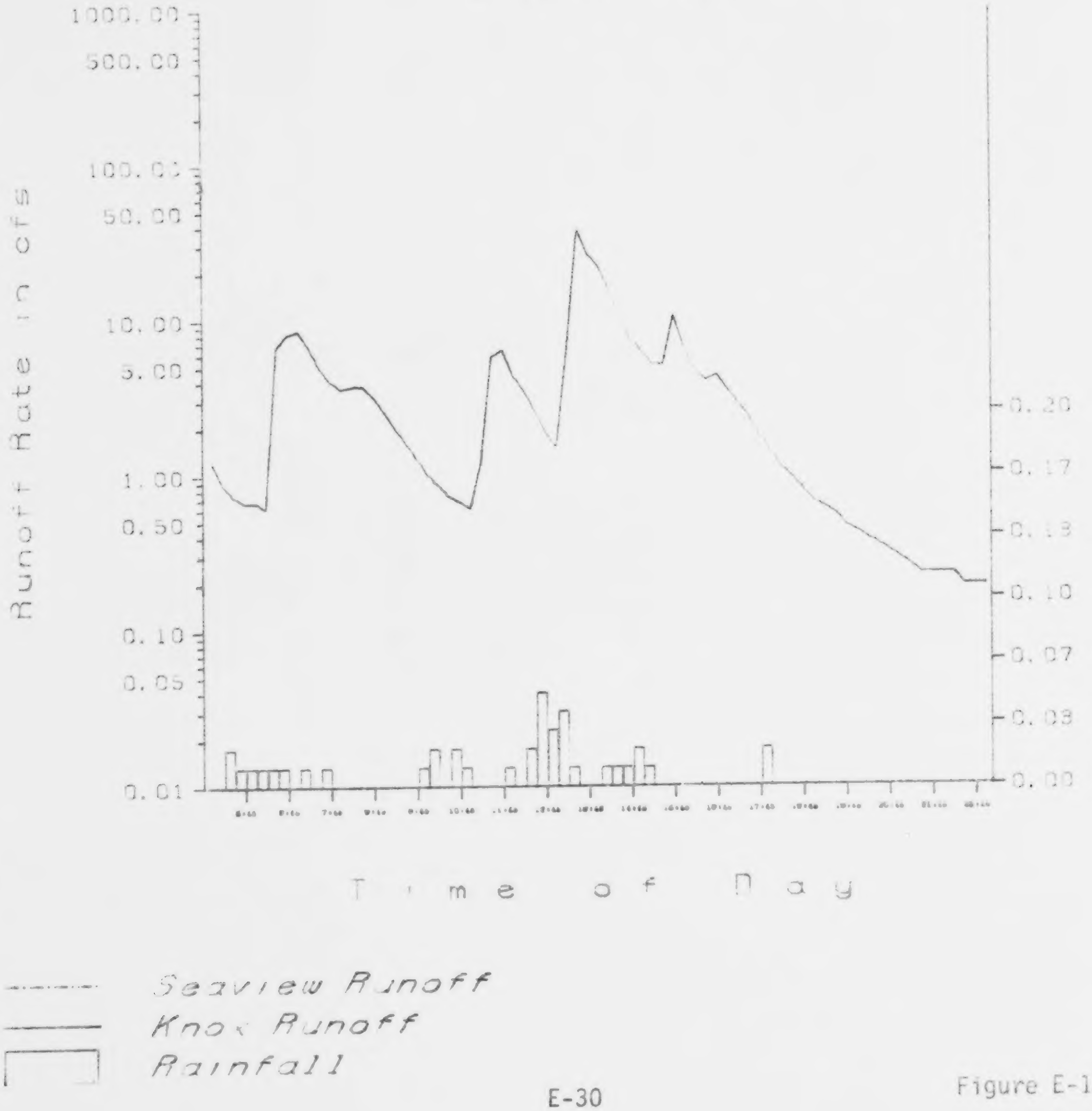

Figure E-1

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Basins Stations

Storm of JANUARY 7 & 8 , 1979
STORM "5"

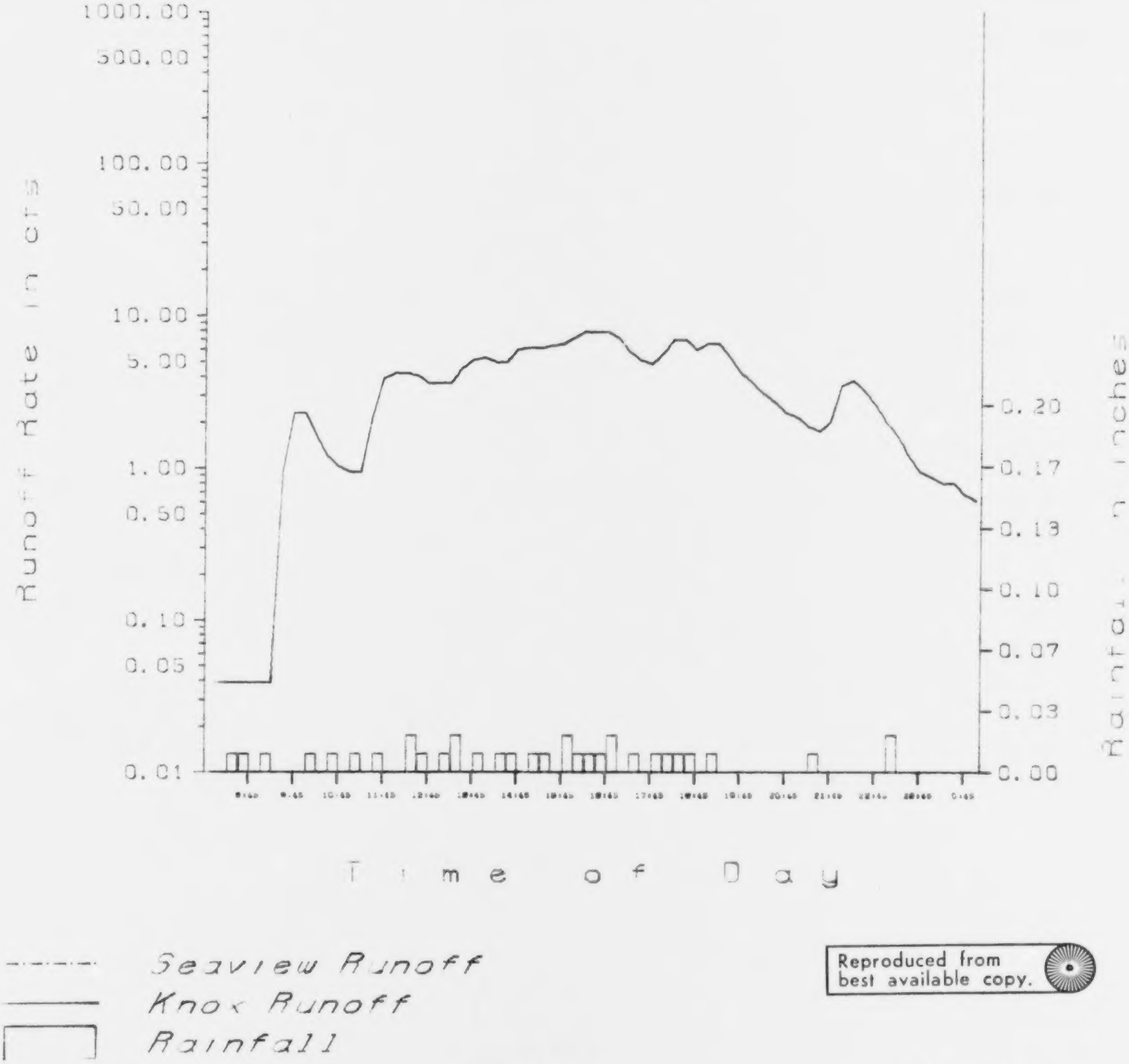

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Figure E-2

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of JANUARY 8, 1979
STORM "C" - 1979

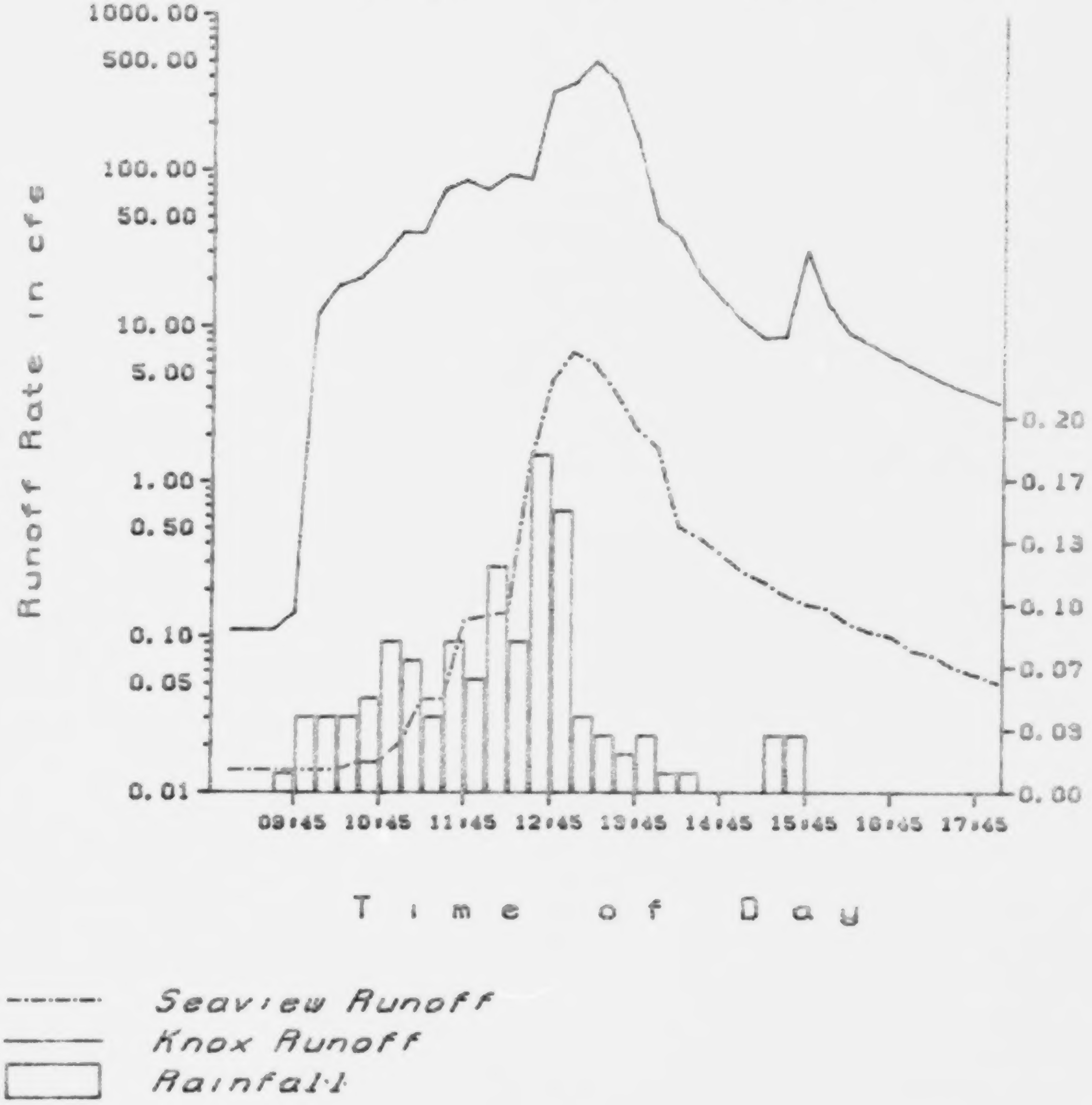


Figure E-3

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of JANUARY 10 & 11, 1979
STORM "D"

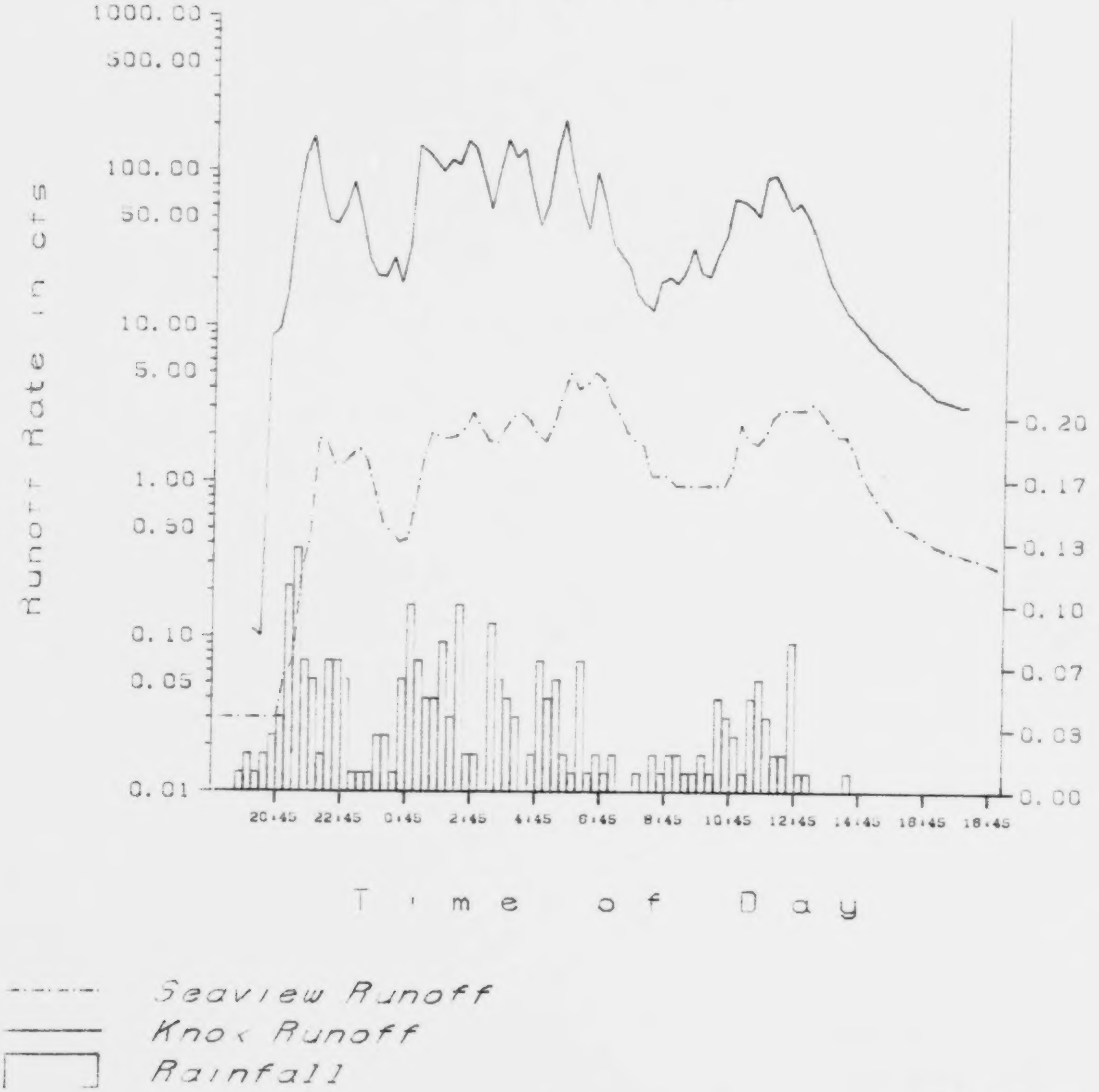


Figure E-4

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of JANUARY 14, 1979
STORM "E"

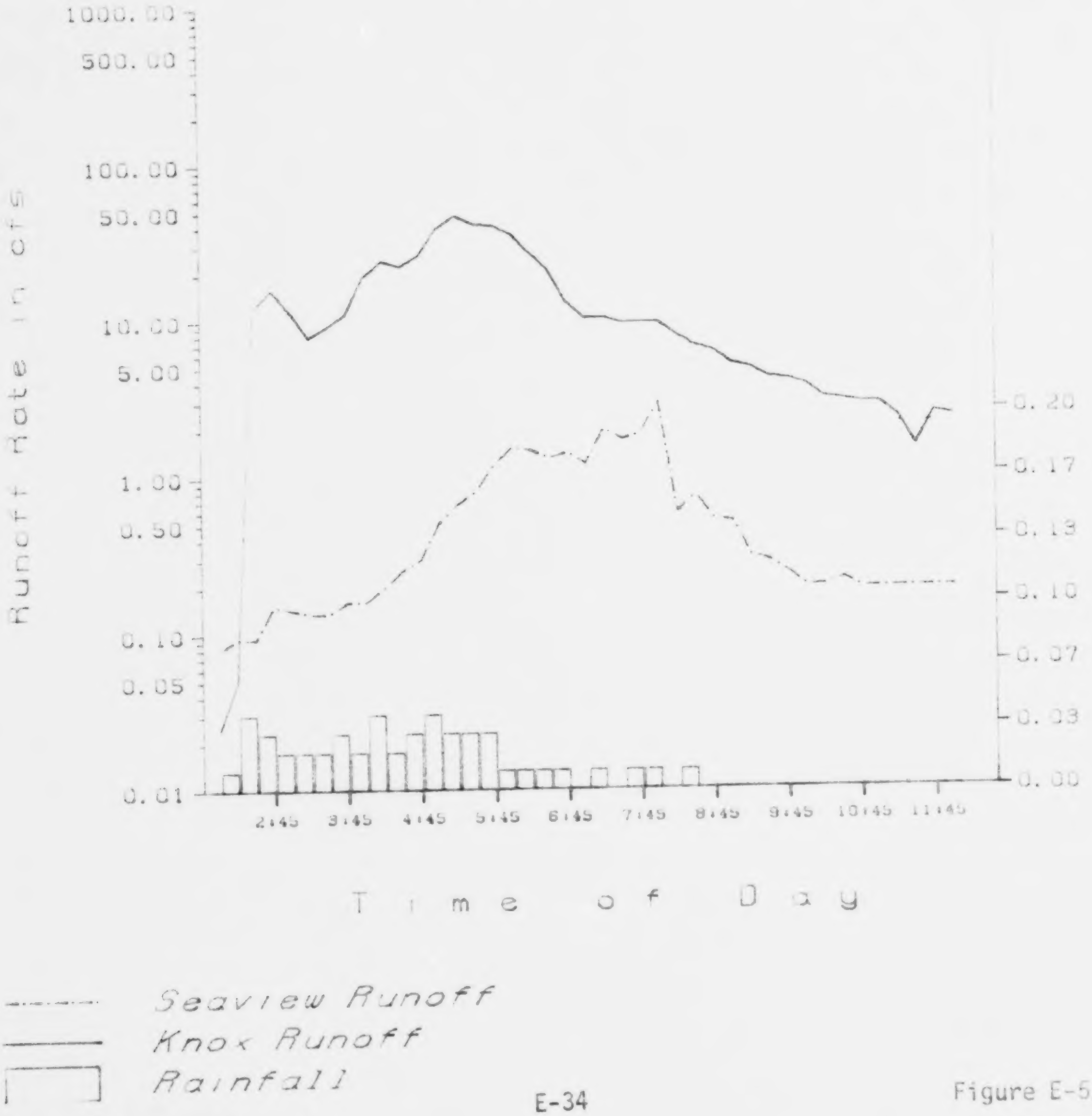


Figure E-5

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 13 & 14, 1979
STORM "F"

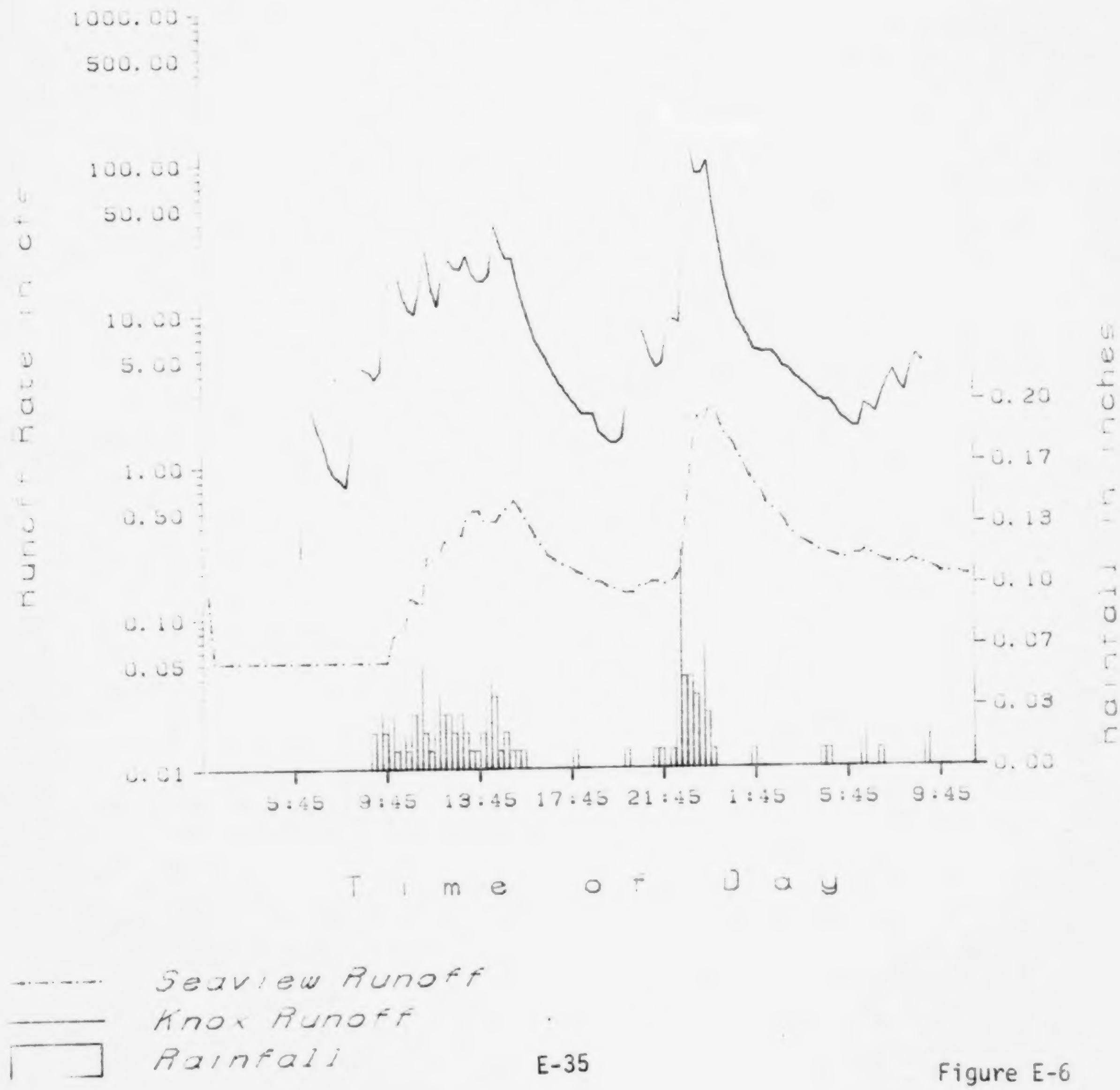


Figure E-6

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 15 & 16, 1979
STORM "G"

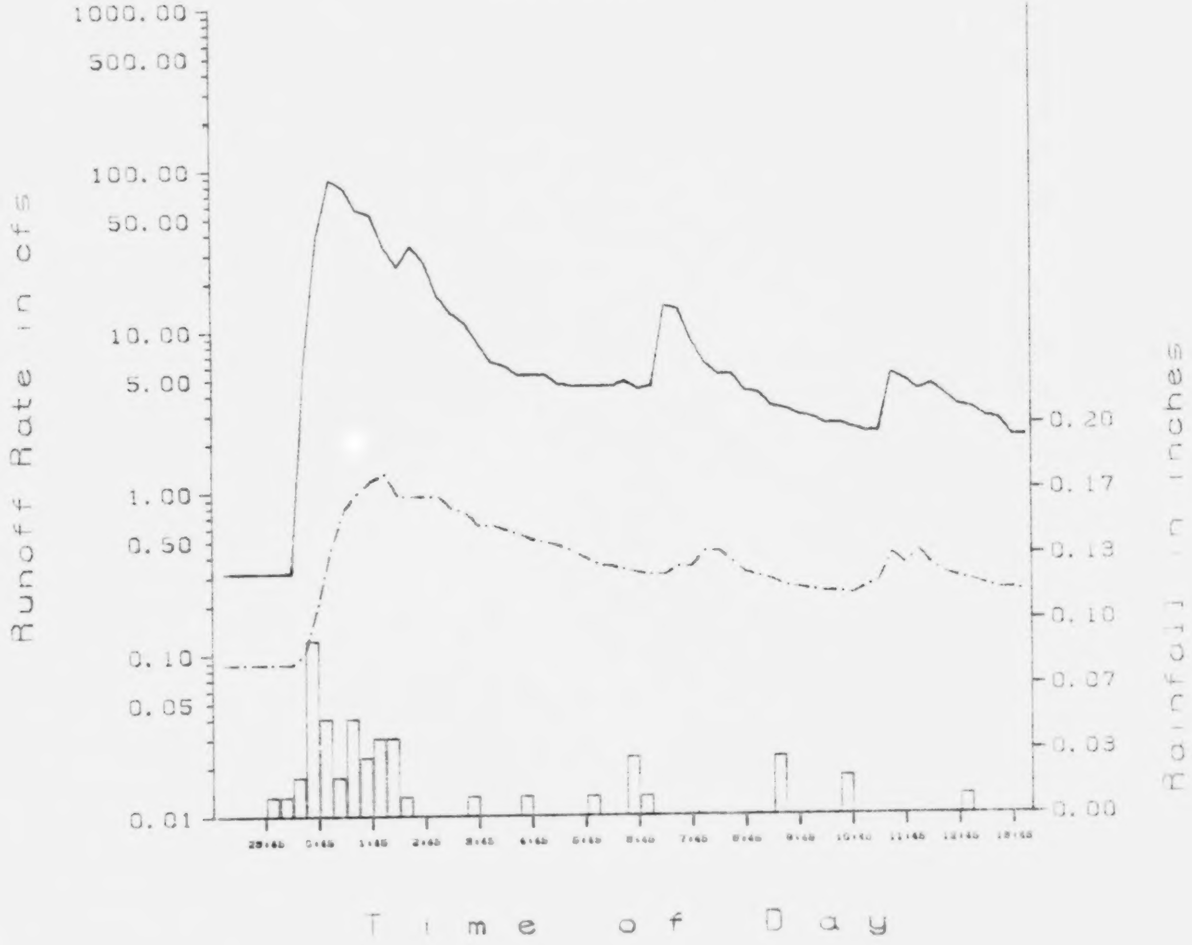


Figure E-7

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 18 & 19, 1979
STORM "H"

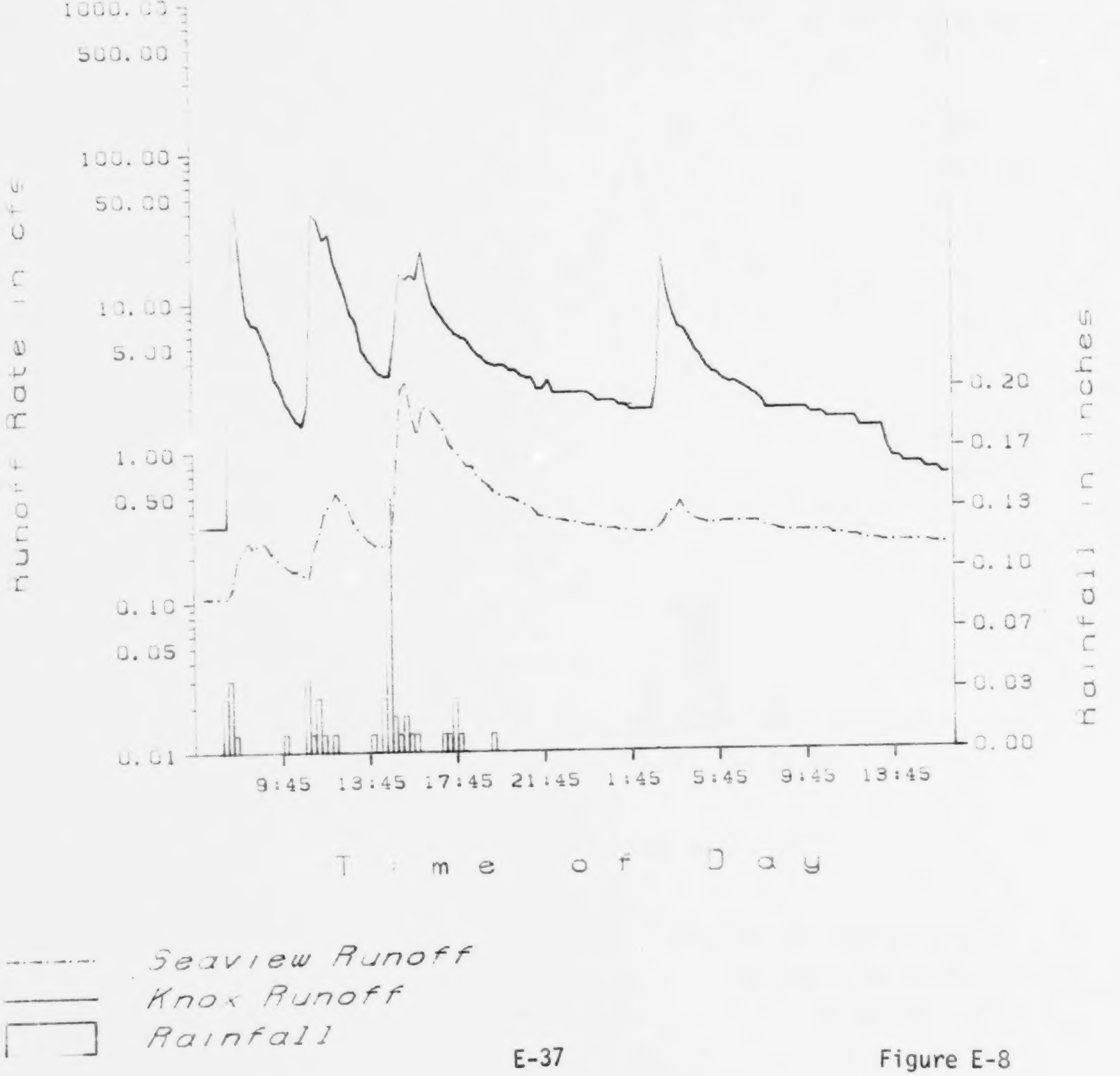


Figure E-8

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 20 - 21, 1979
STORM "I" - 1979

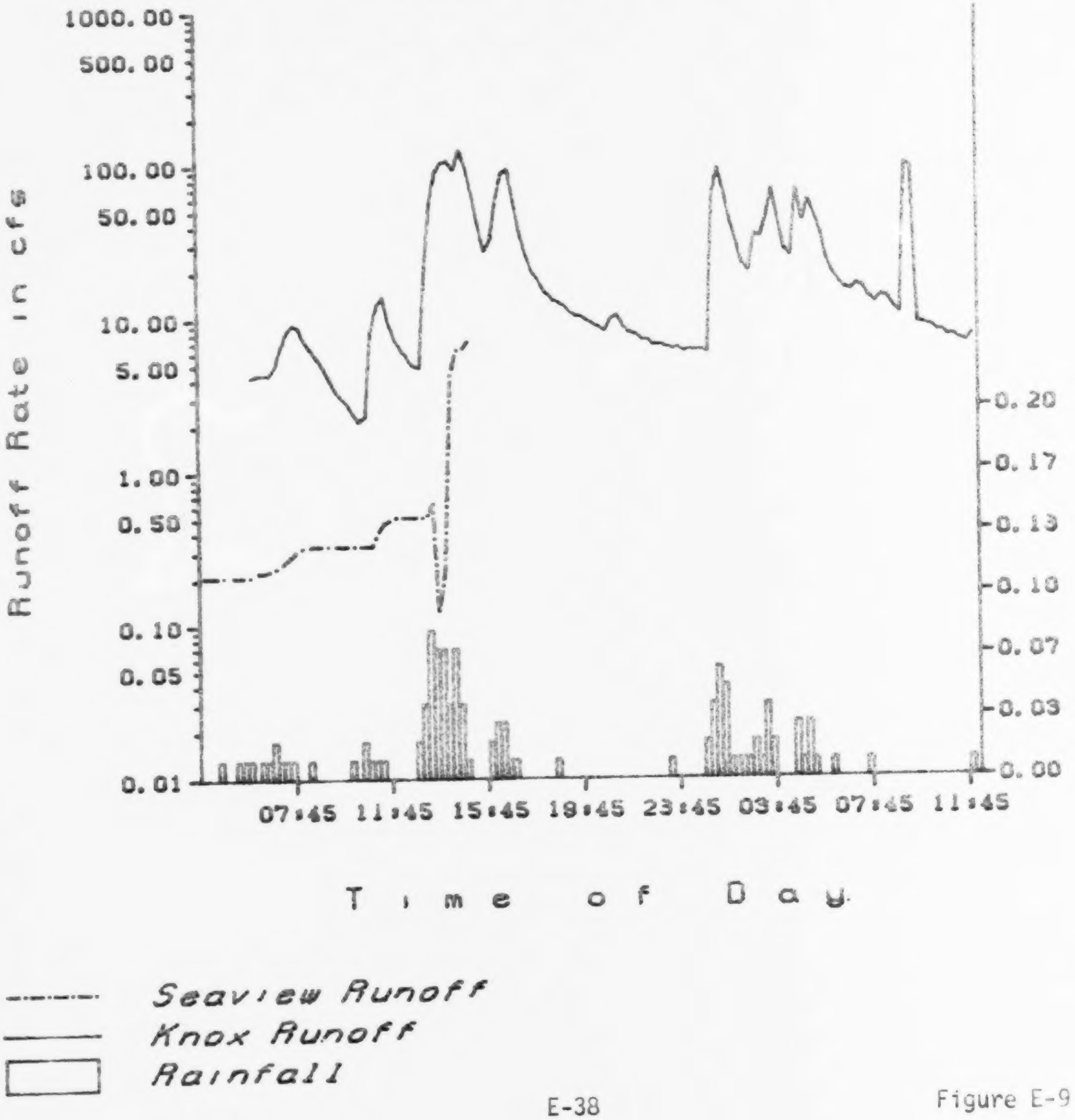
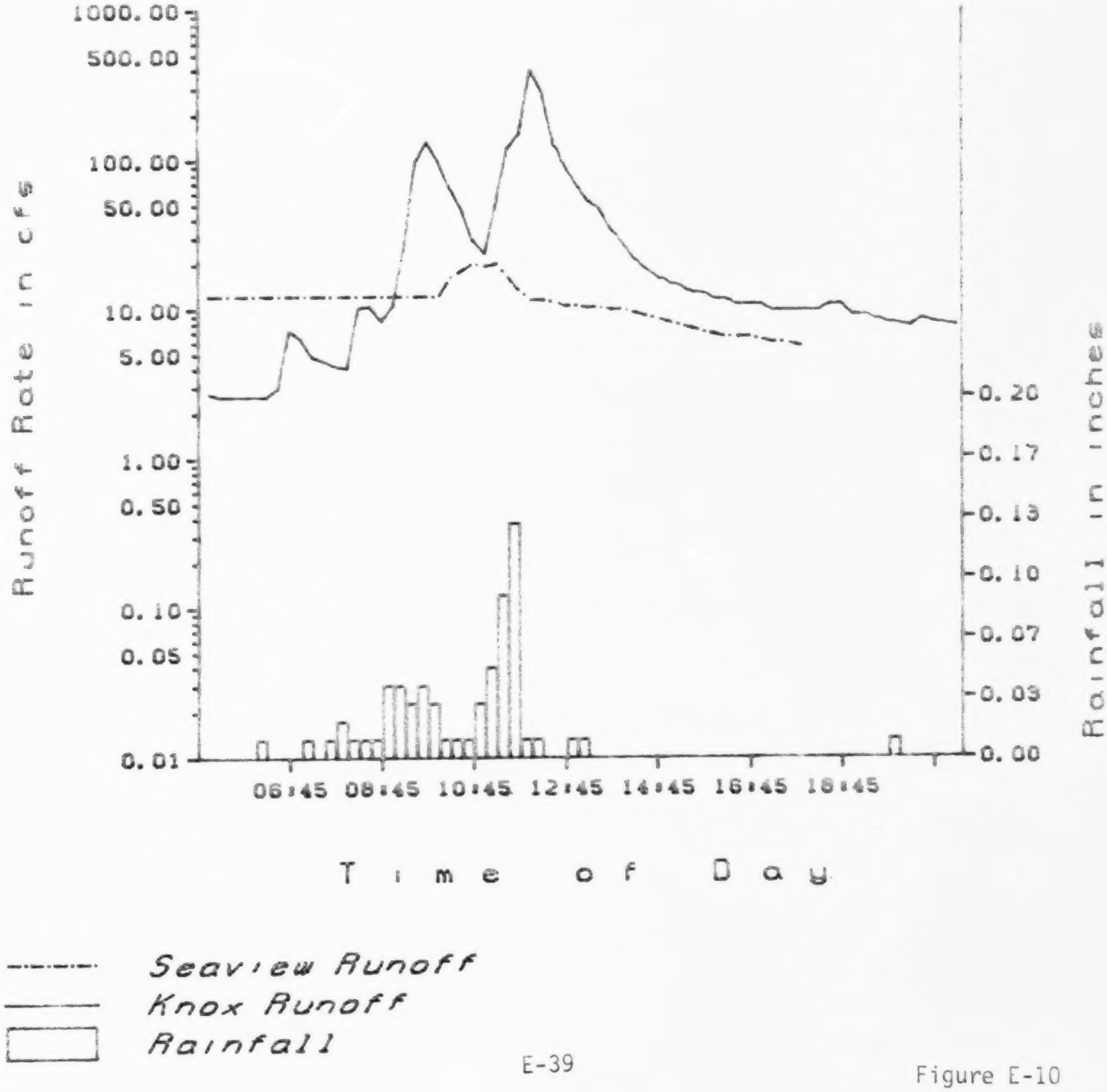


Figure E-9



San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 22. 1979
STORM "J" - 1979

Figure E-10

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of FEBRUARY 28 - MARCH 1, 1979
STØRM "K" - 1979

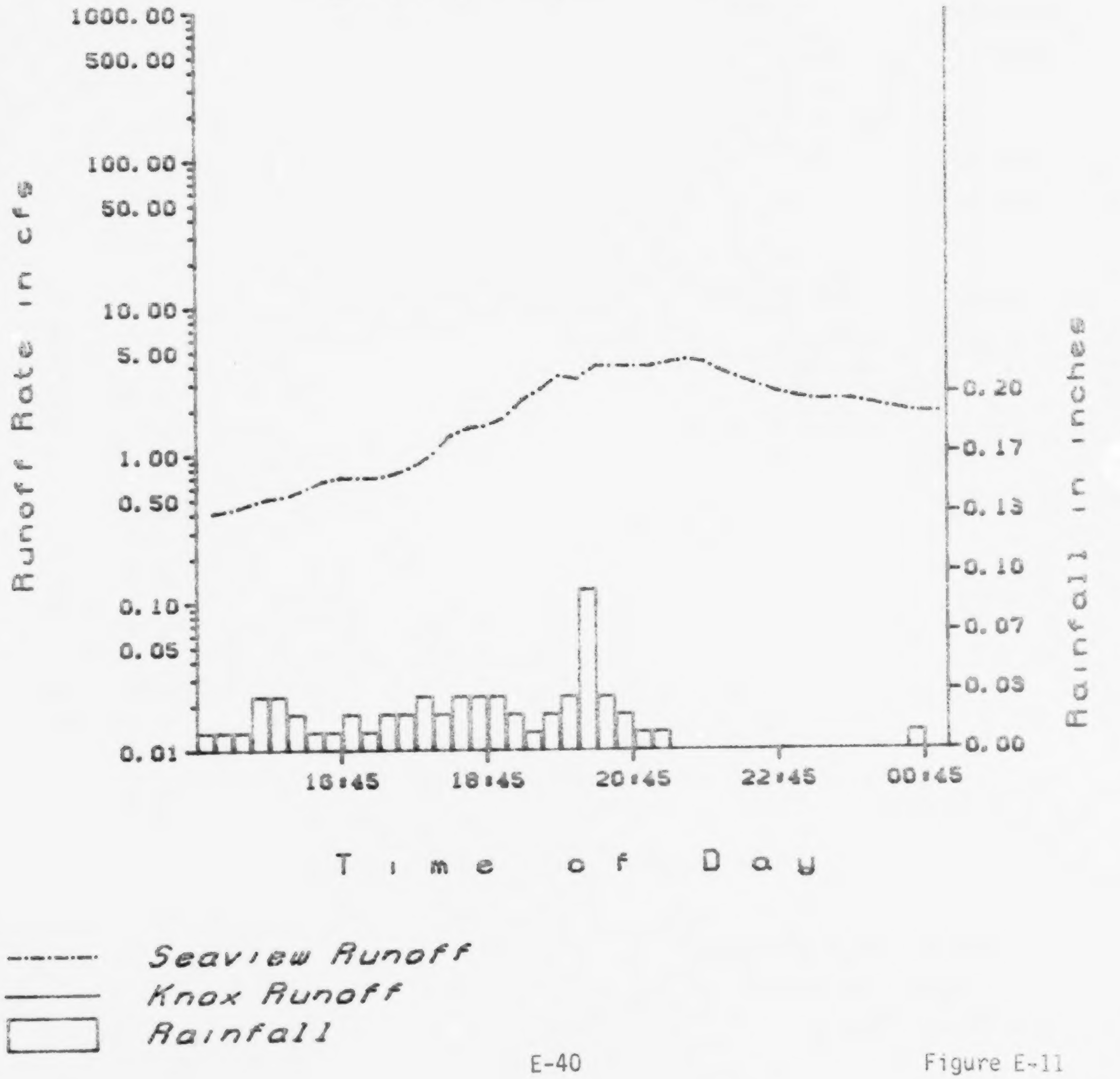


Figure E-11

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gasing Stations

Storm of MARCH 15 - 17, 1979
STORM "L" - 1979

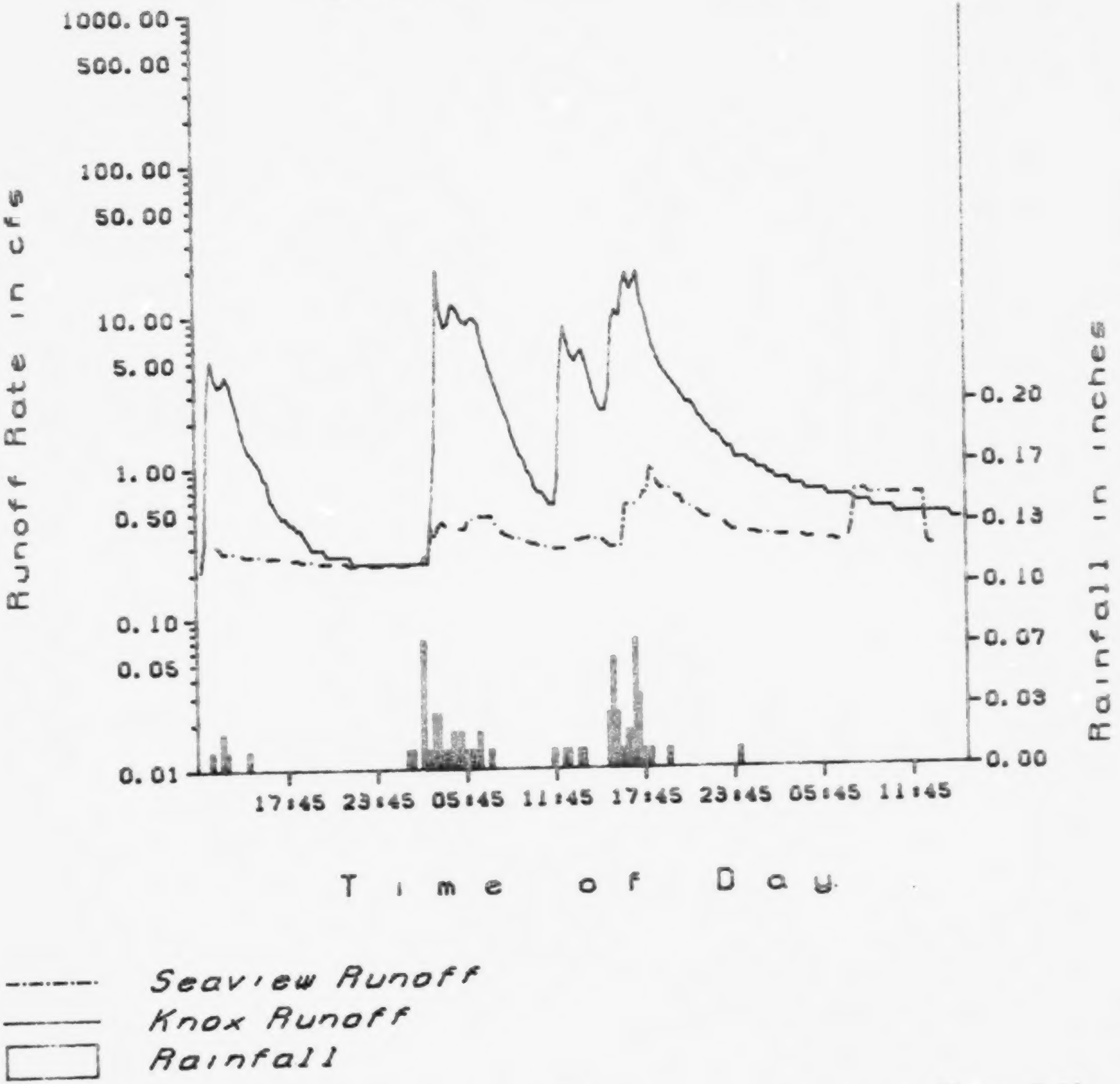


Figure E-12

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Basins Stations

Storm of MARCH 26 - 28, 1979
STORM "M" - 1979

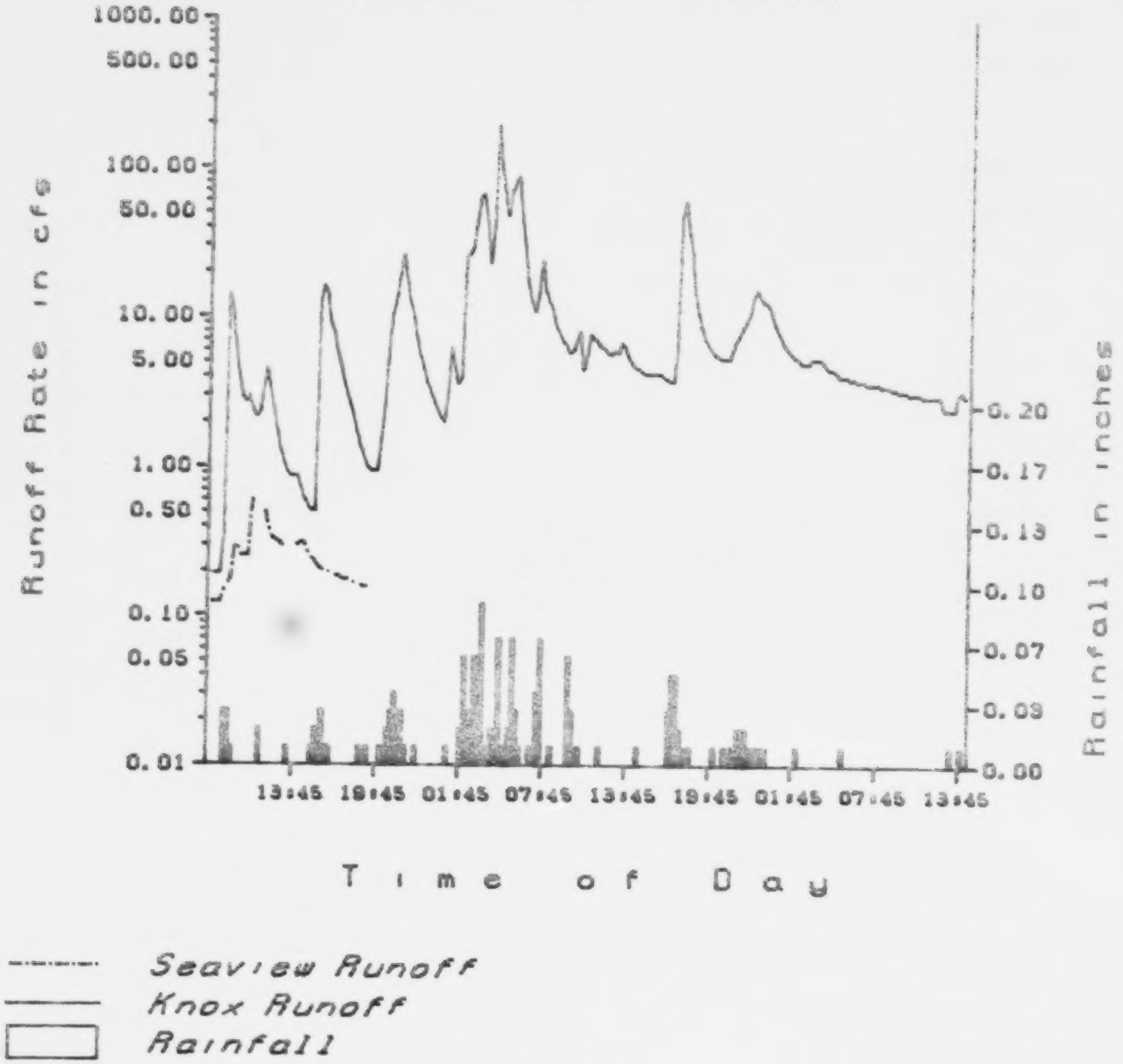
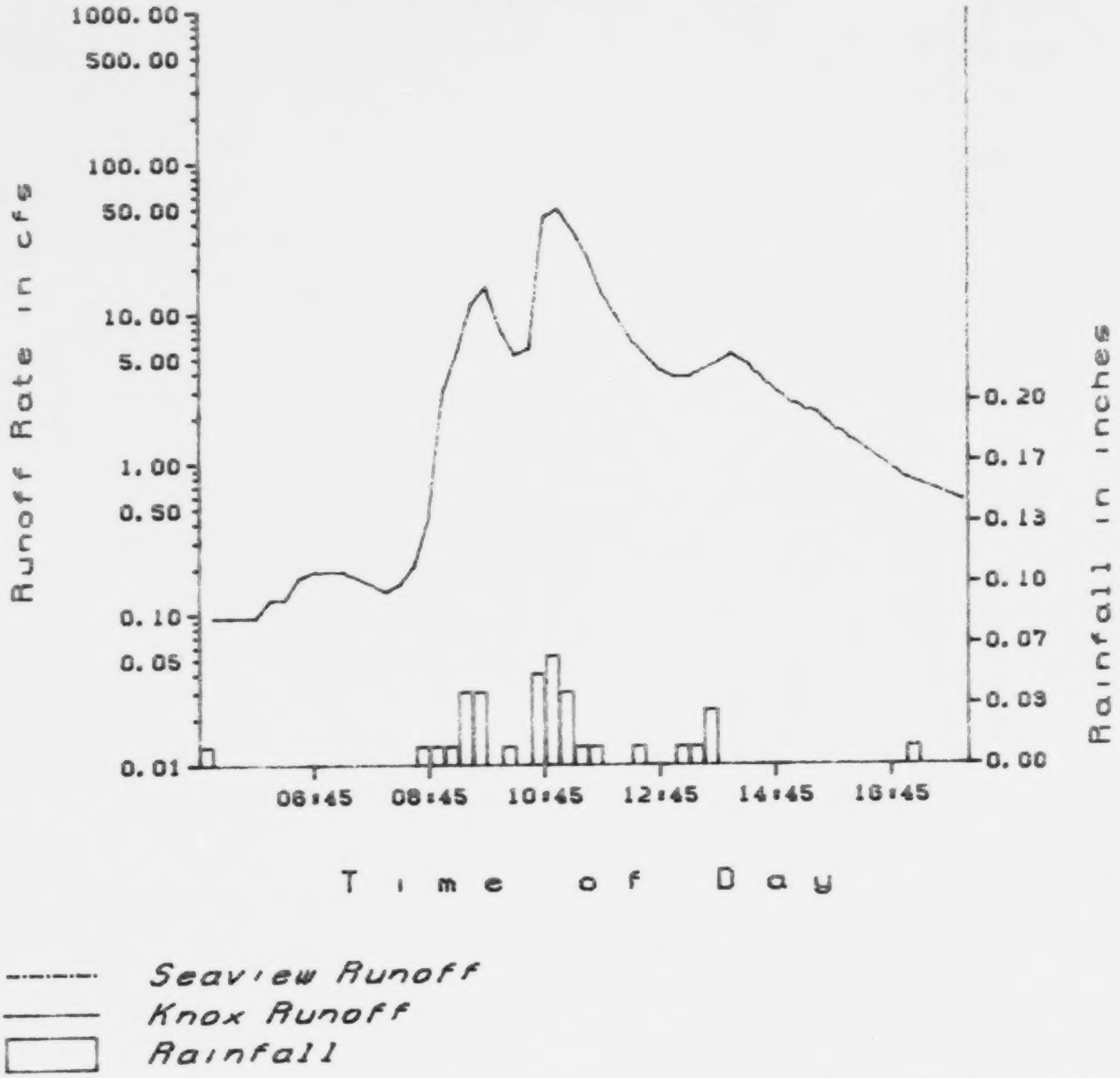


Figure E-13



San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gasing Stations

Storm of APRIL 26, 1979
STORM "N" - 1979

Figure E-14

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of October 18 - 20, 1979
STORM #1 - 1980

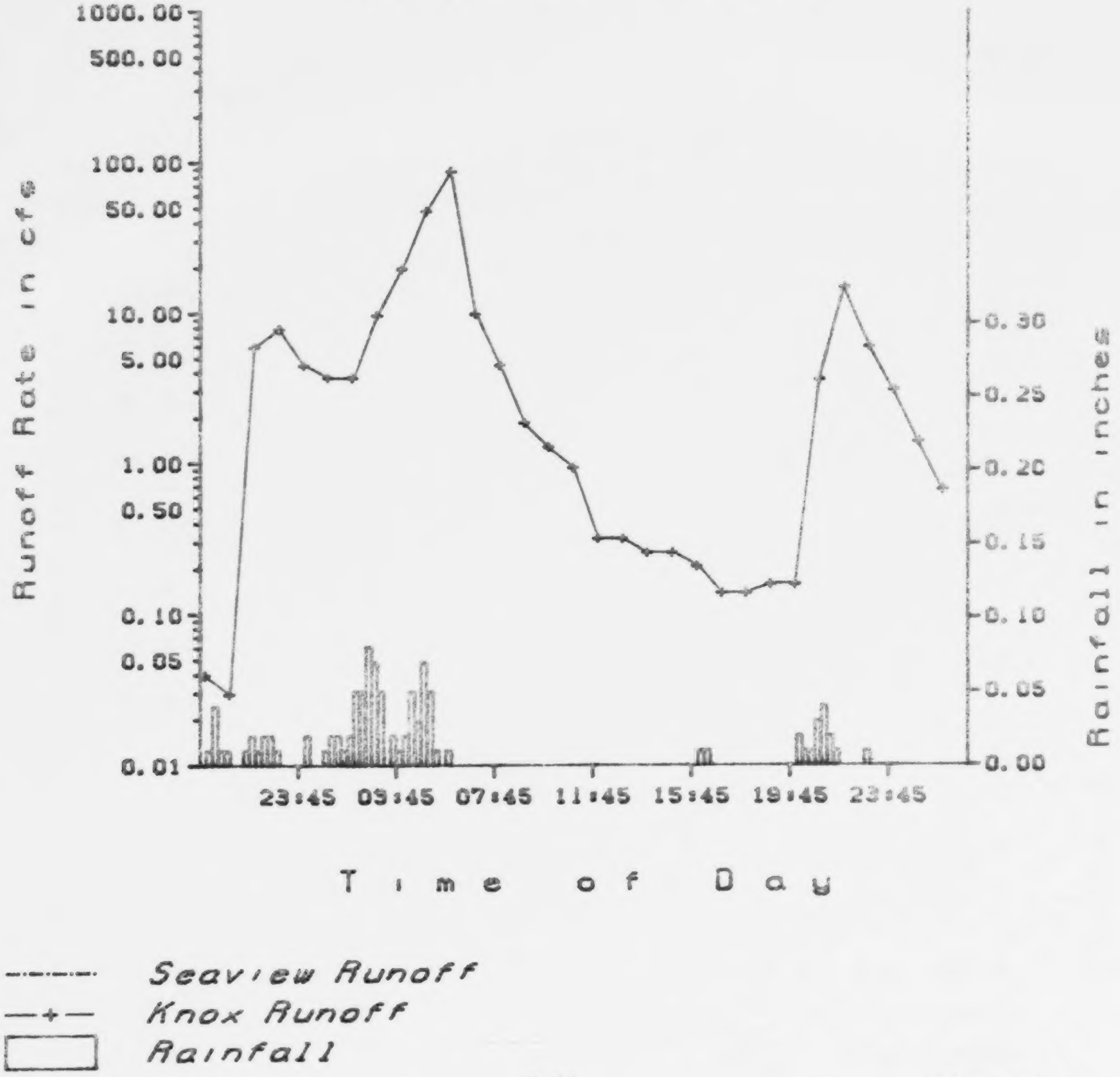


Figure E-15

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of November 3, 1979
STORM #3 - 1980

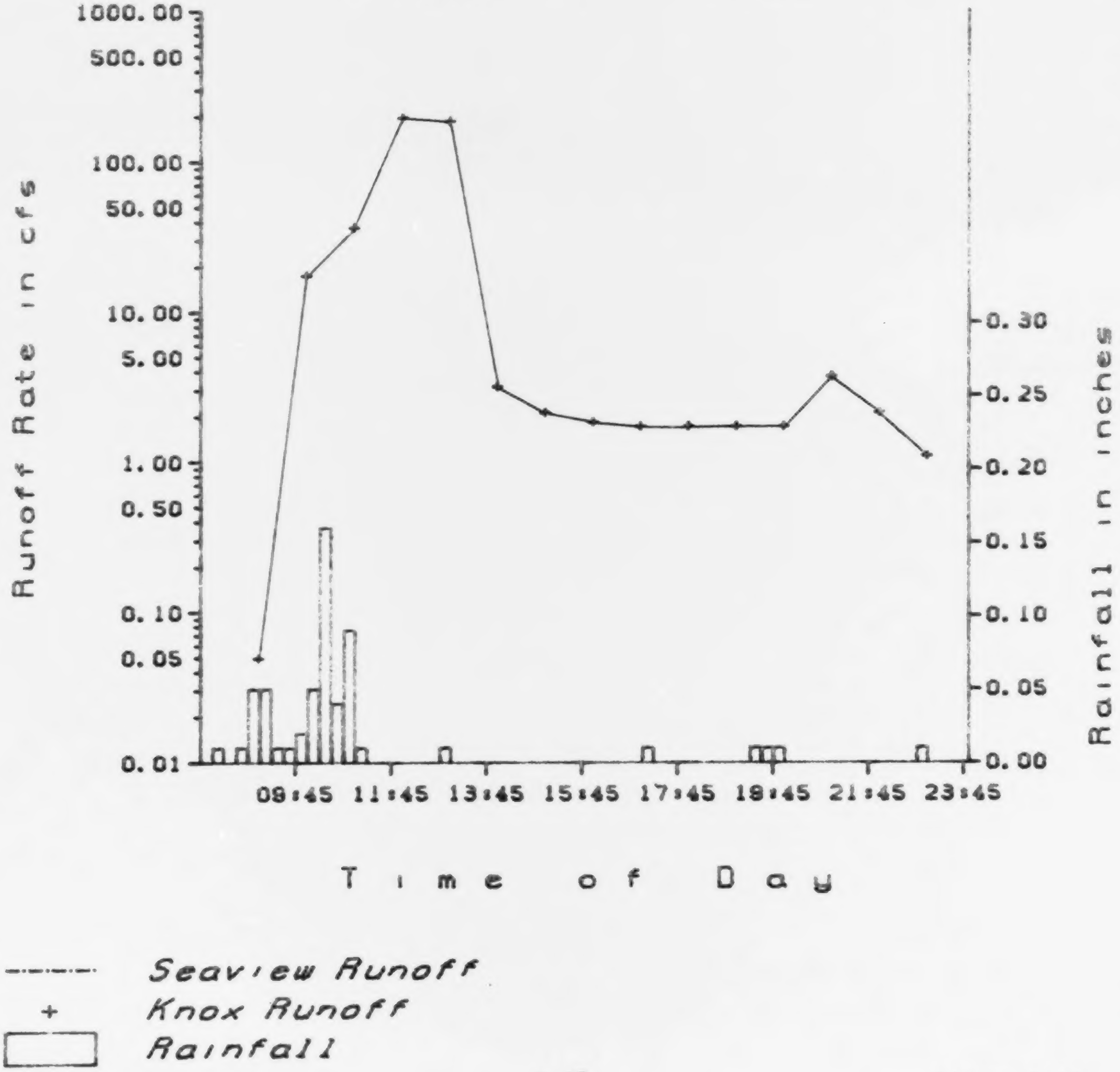


Figure E-16

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of November 16 - 17, 1979
STORM #4 - 1980

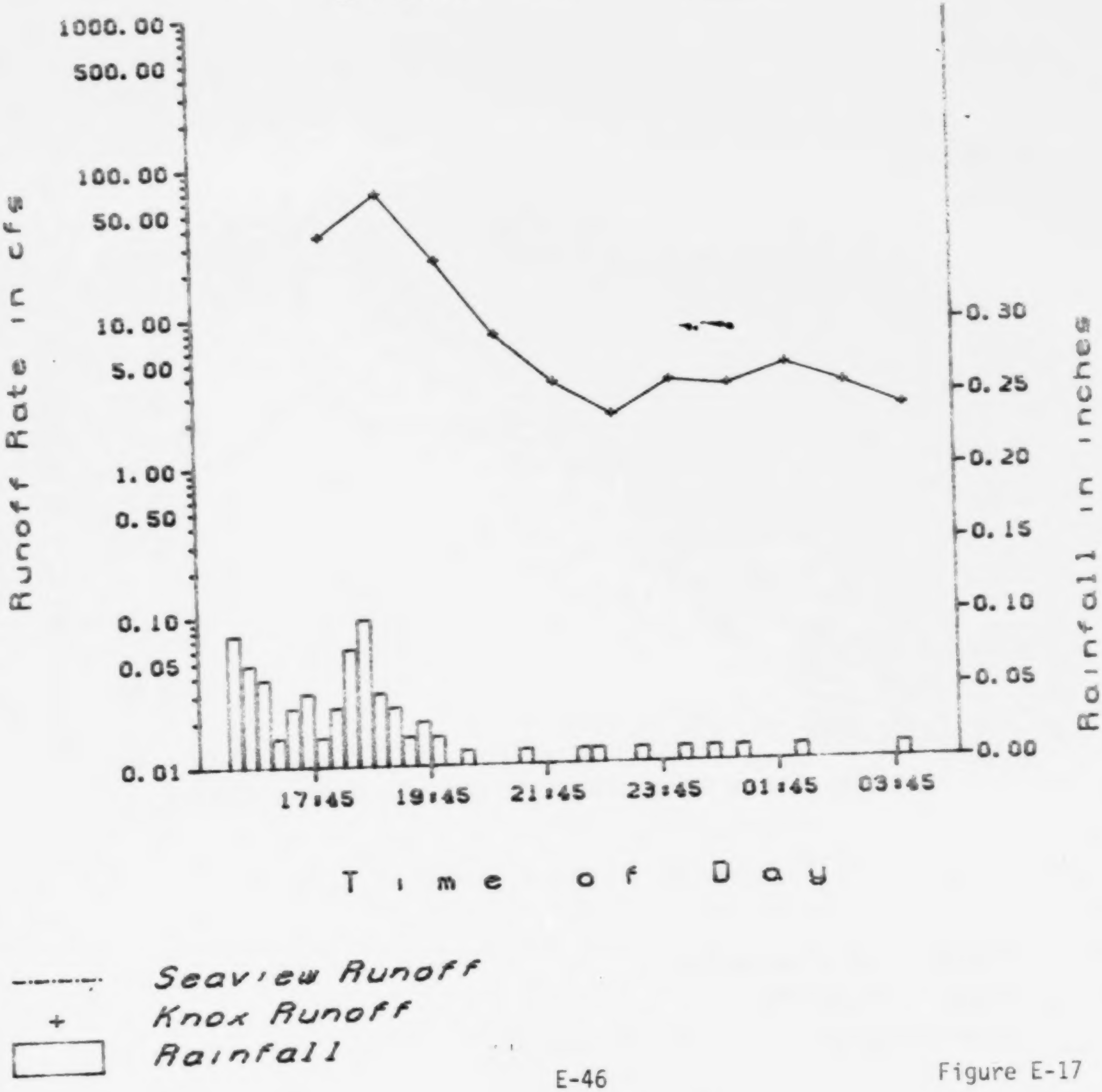


Figure E-17

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of November 22 - 25, 1979
STORM #5 - 1980

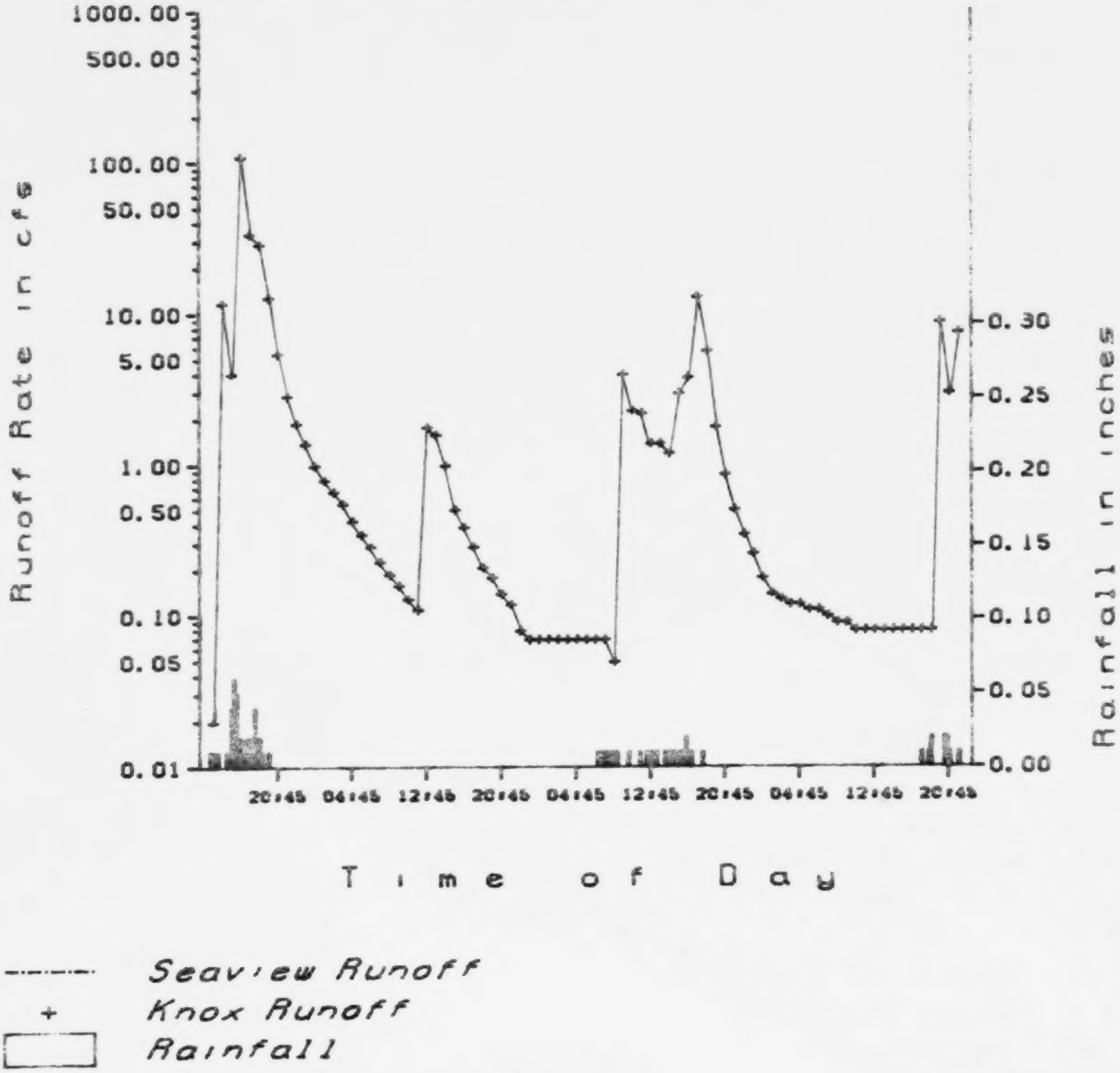


Figure E-18

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of December 19 - 20, 1979
STORM #6 - 1980

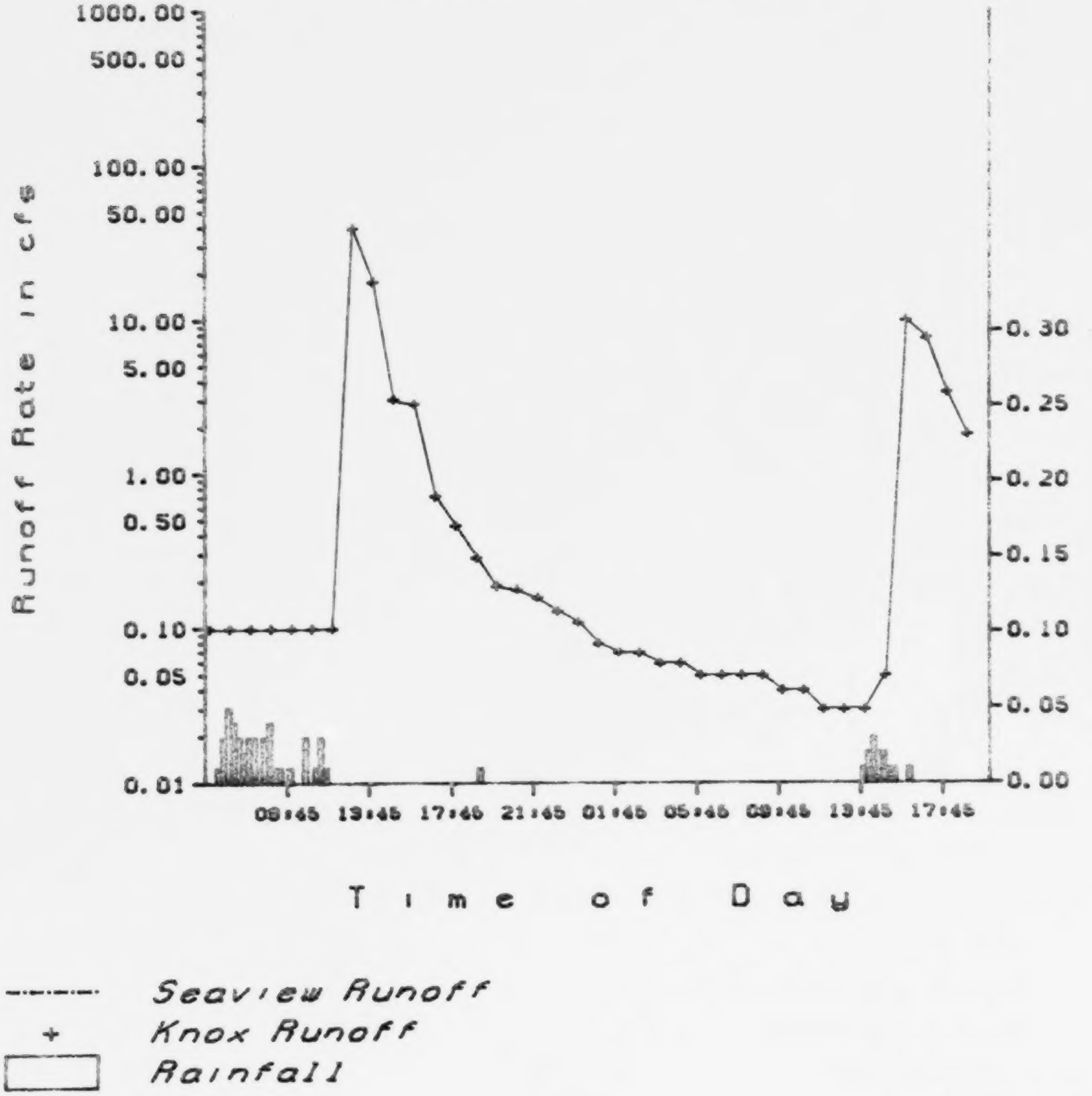


Figure E-19

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of December 23 - 26, 1979
STORM #7 - 1980

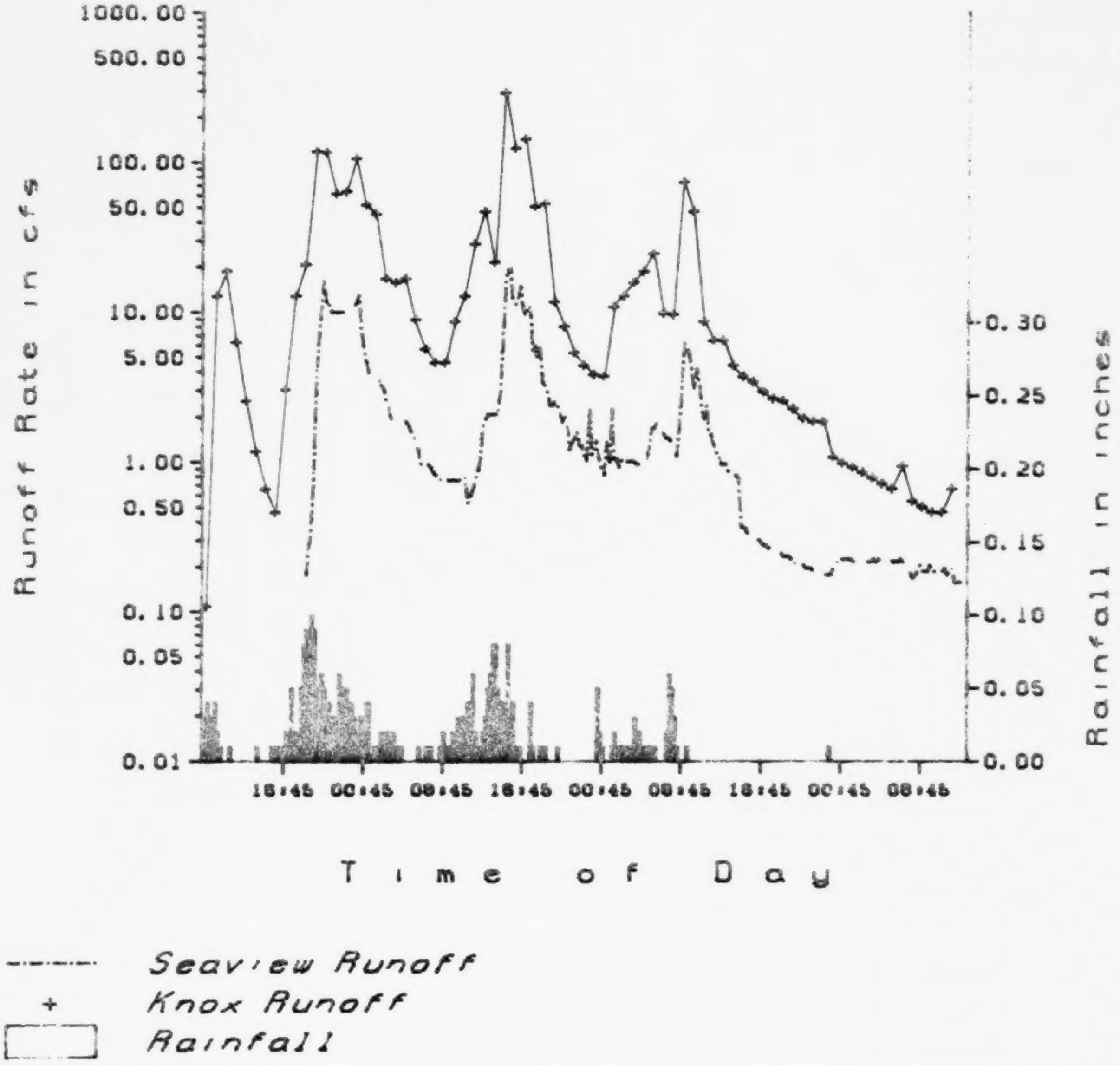


Figure E-20

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of December 30 - 31, 1979
STORM #8 - 1980

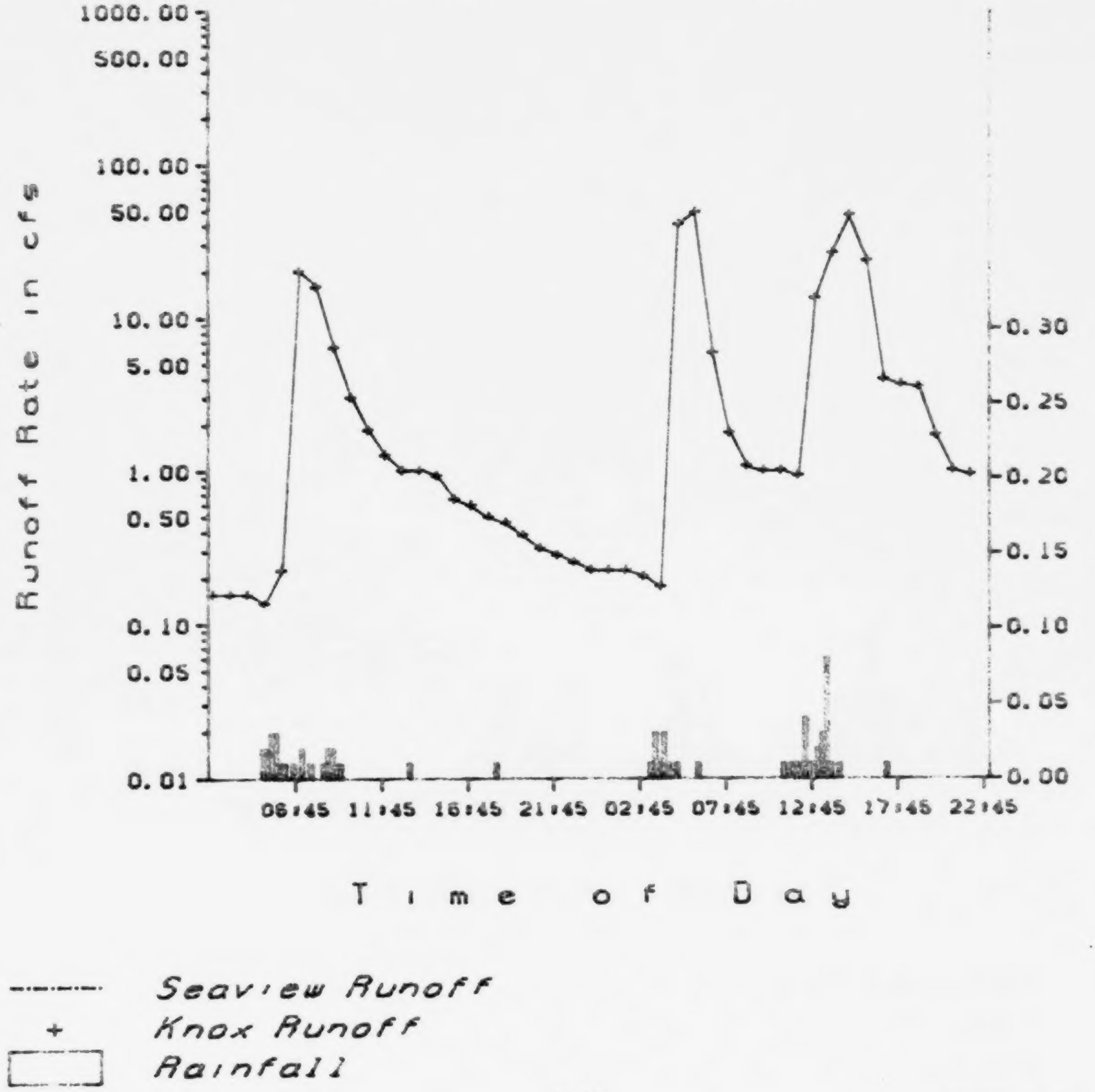


Figure E-21

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of January 10 - 18, 1980
STORM #9 - 1980

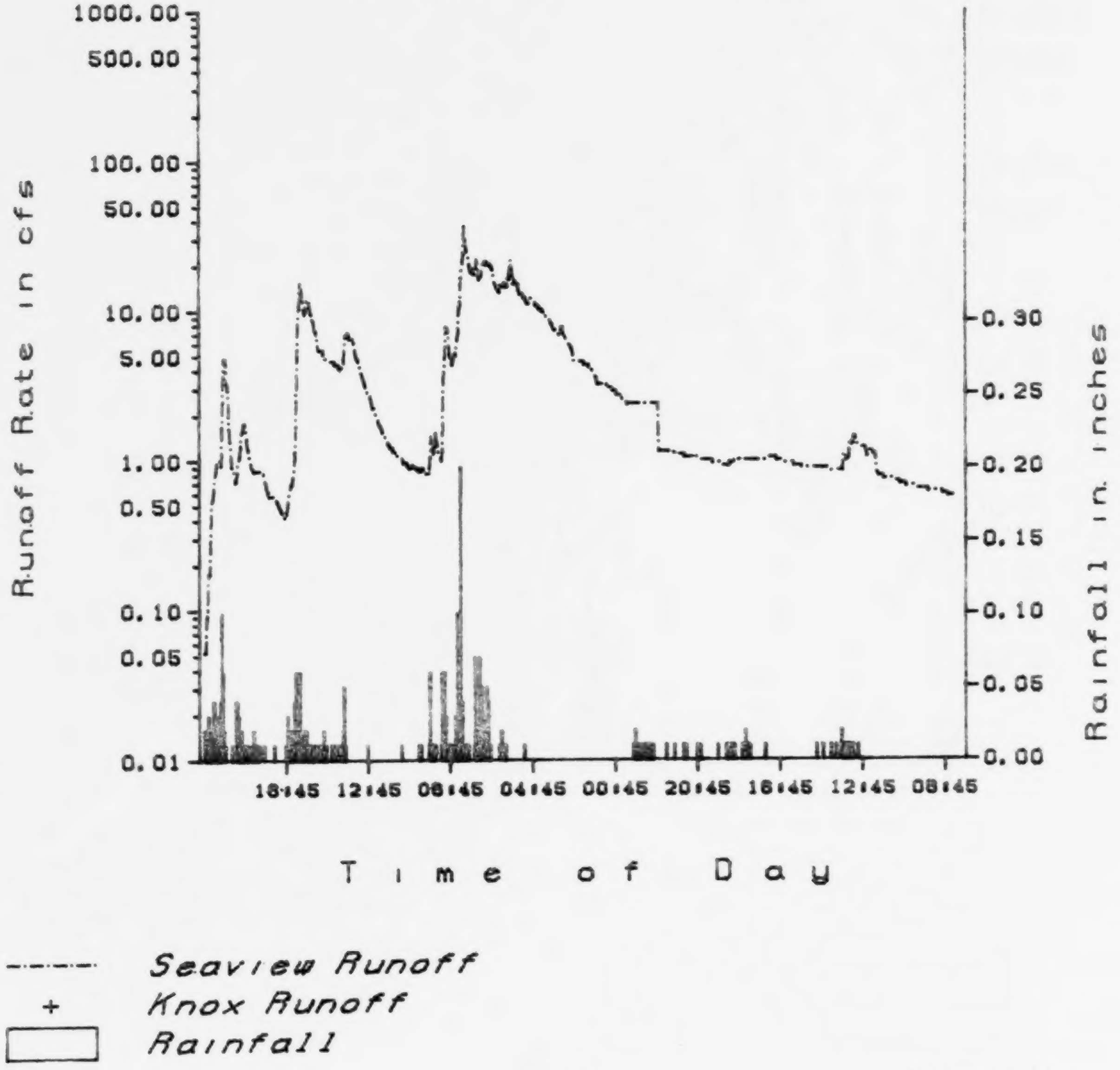


Figure E-22

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of February 14 - 24, 1980
STORM #10 - 1980

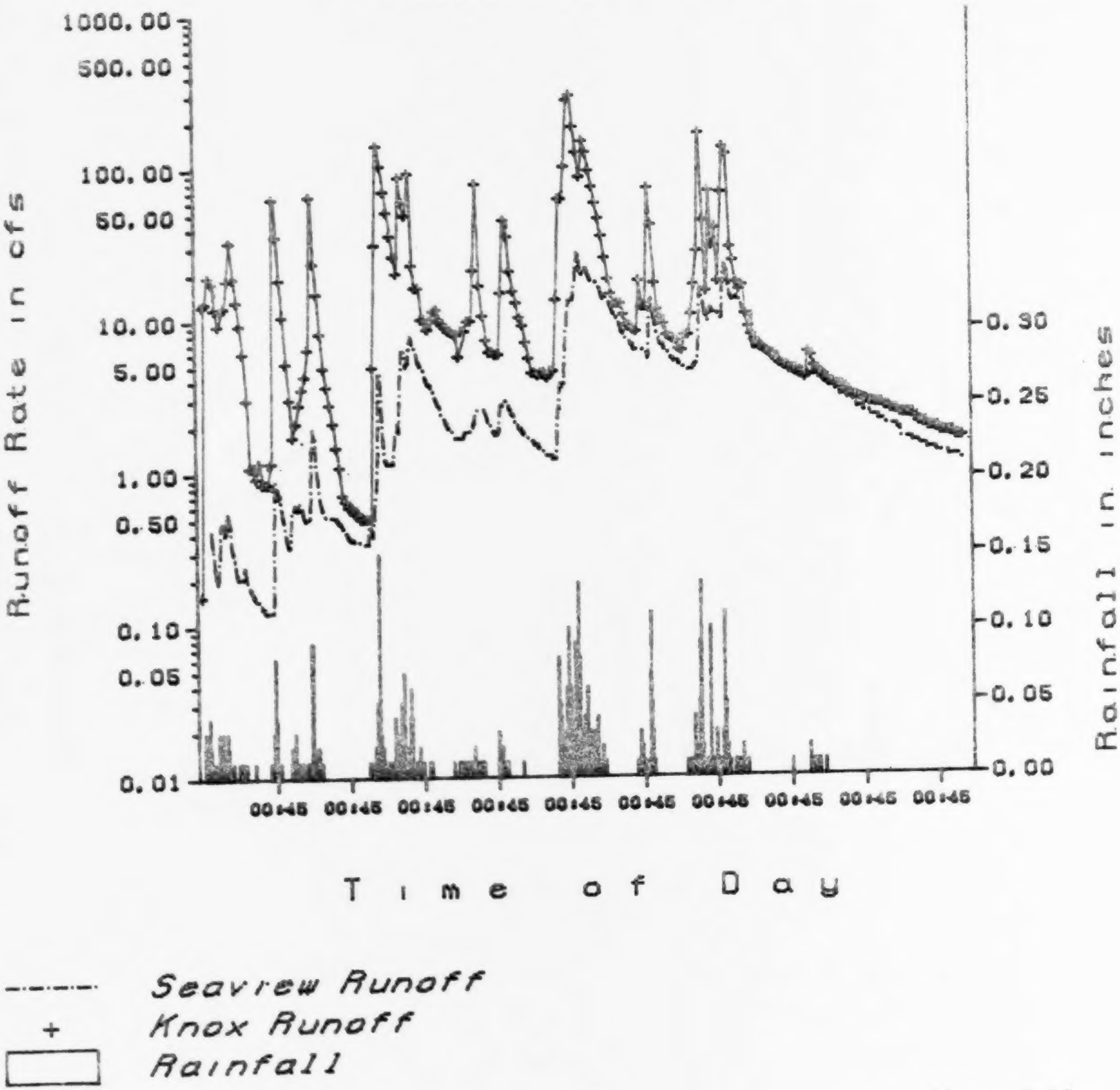


Figure E-23

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of February 25 - 28, 1980
STØRM #11 - 1980

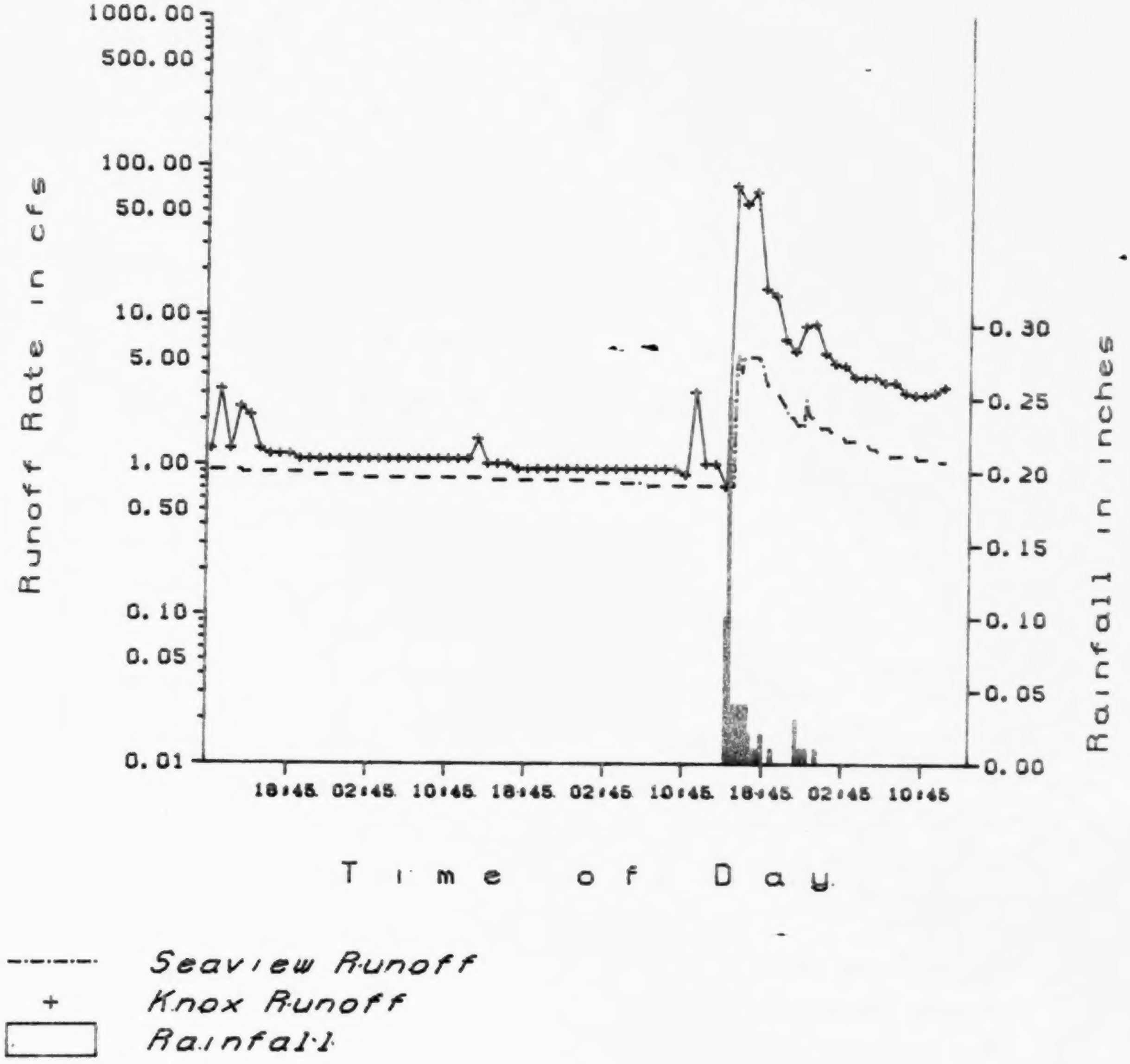


Figure E-24

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of March 2 - 4, 1980
STORM #12 - 1980

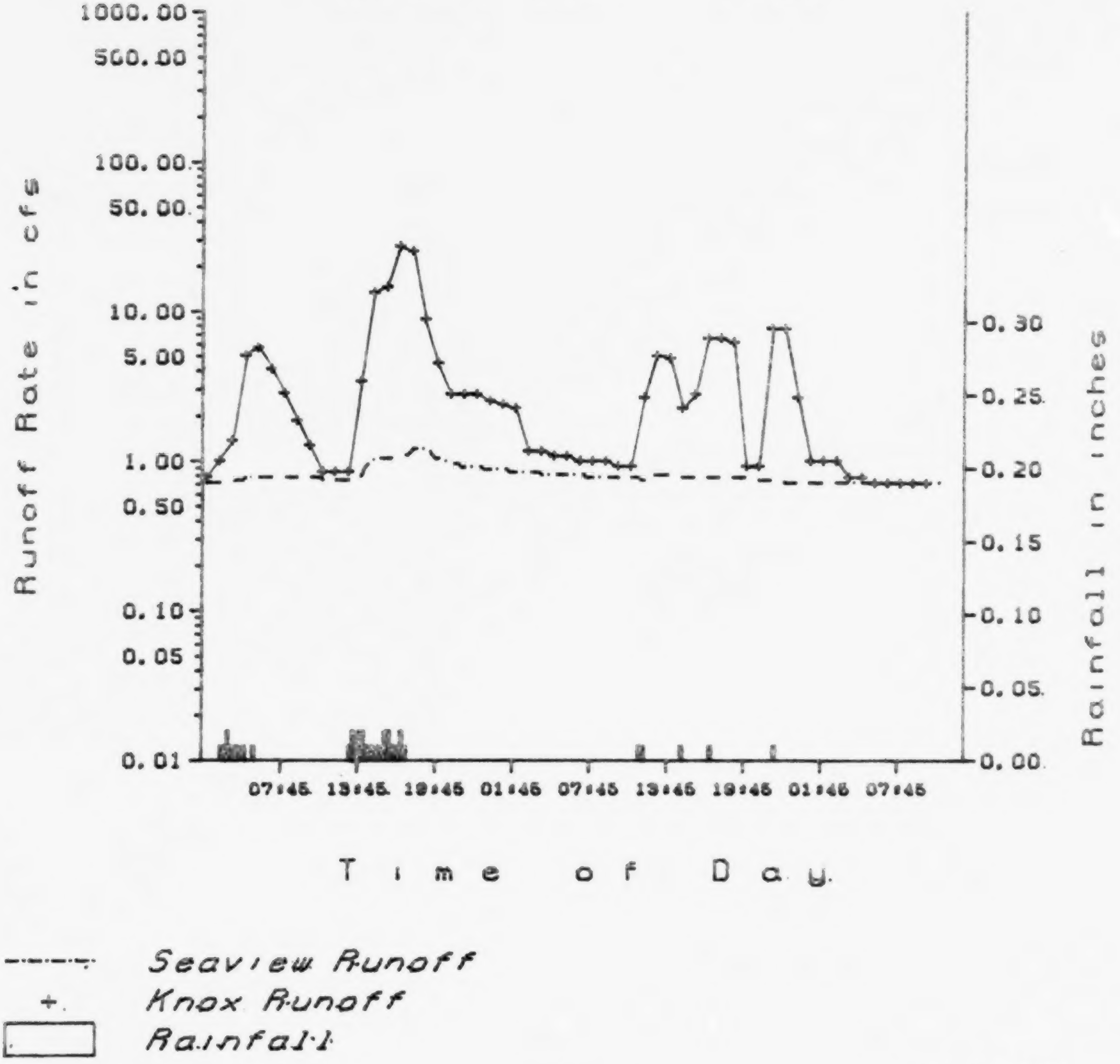


Figure E-25

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of March 4 - 7, 1980
STORM #13 - 1980

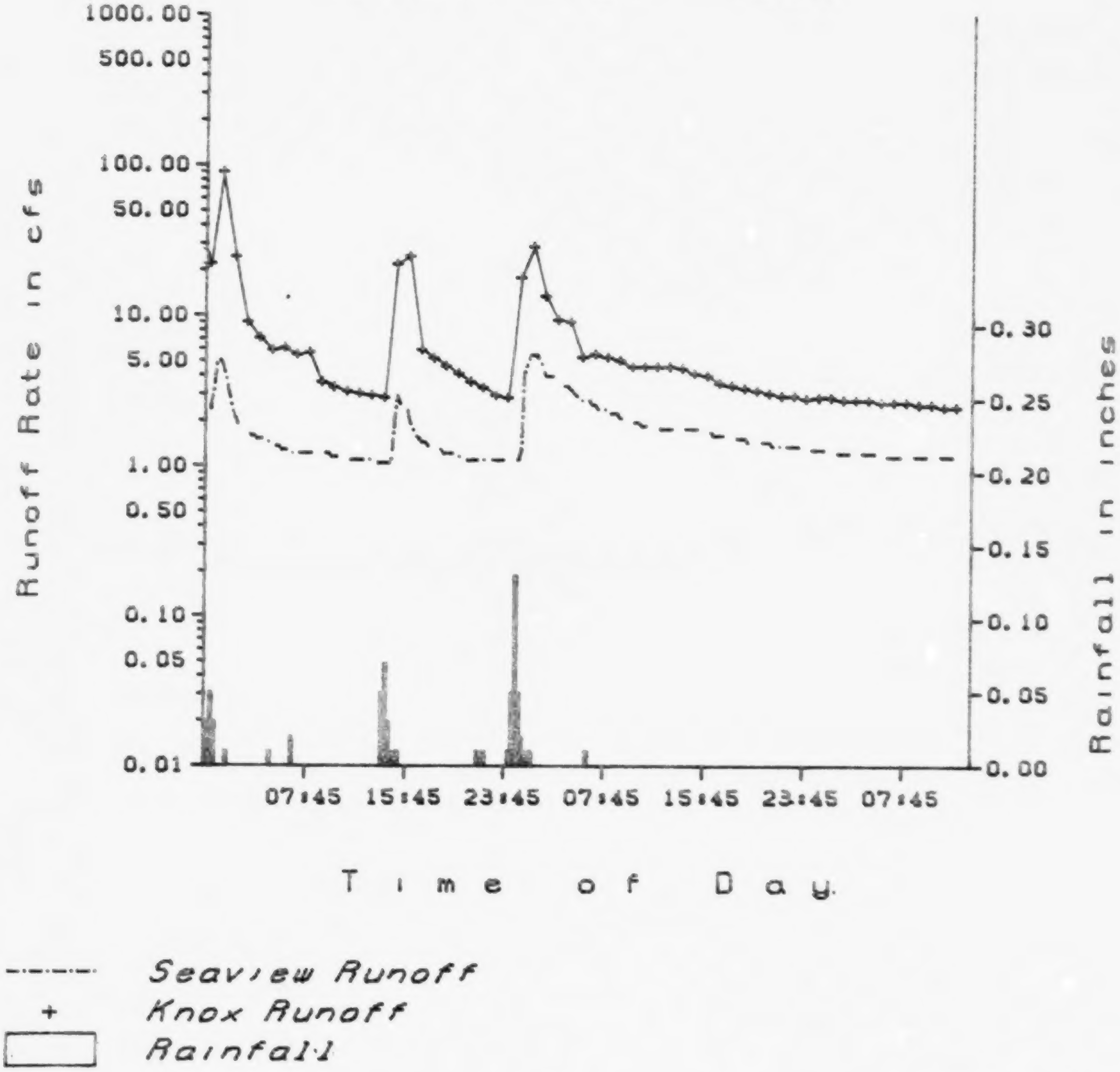


Figure E-26

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of March 25 - 26, 1980
STORM #14 - 1980

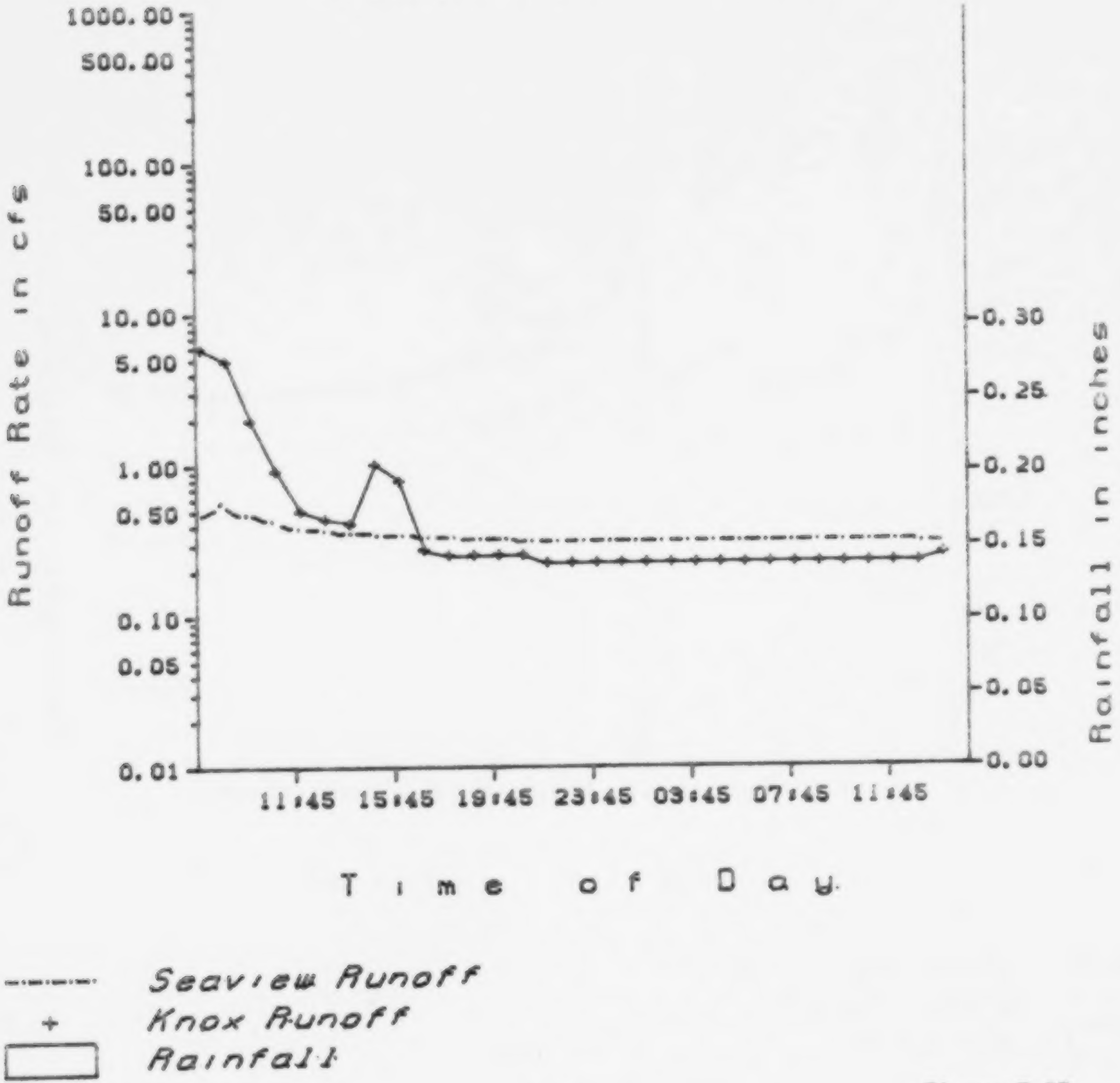
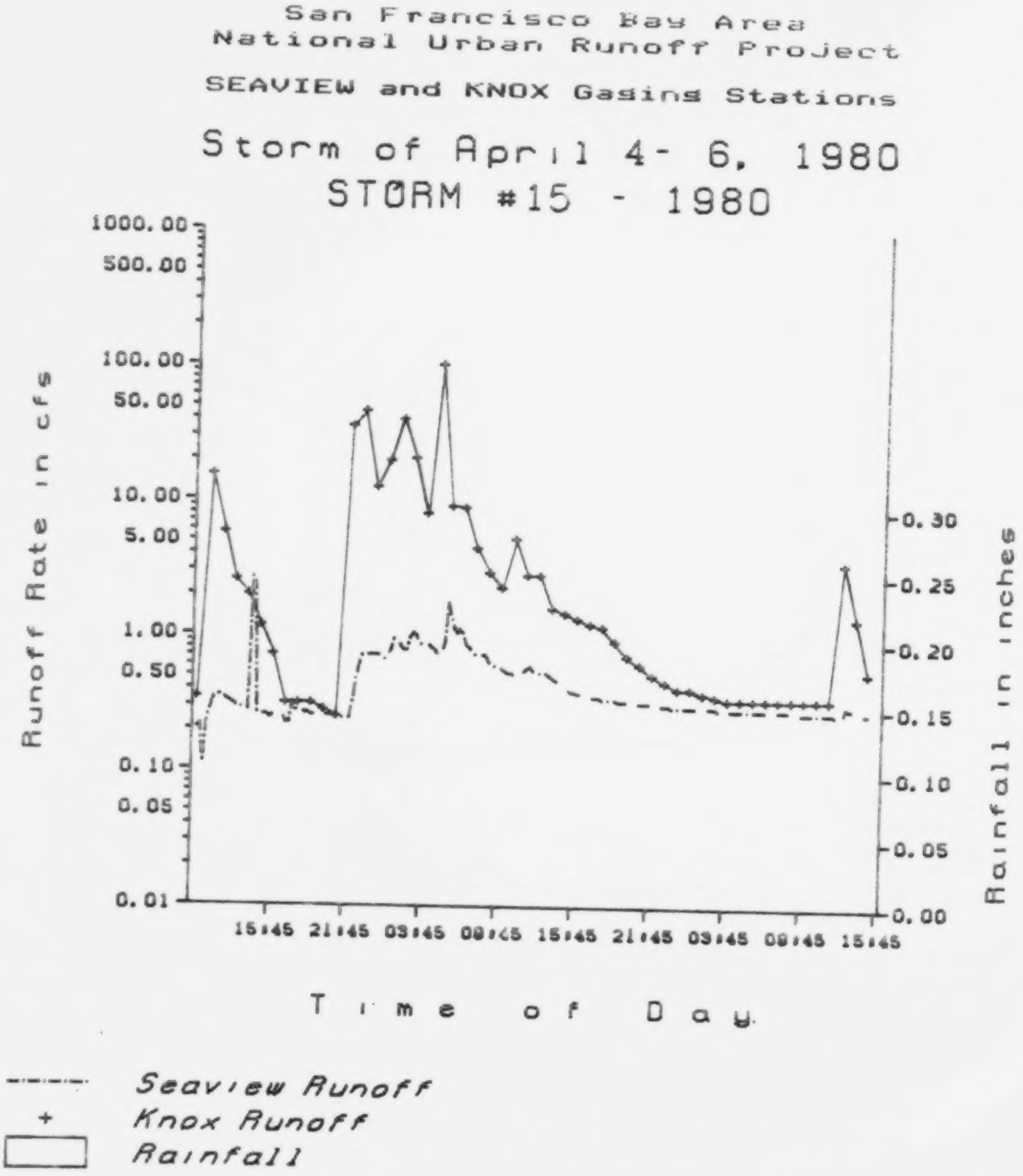


Figure E-27



San Francisco Bay Area
National Urban Runoff Project
SEAVIEW and KNOX Gaging Stations

Storm of April 4- 6, 1980
STORM #15 - 1980

Figure E-28

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of April 20 - 21, 1980
STORM #16 - 1980

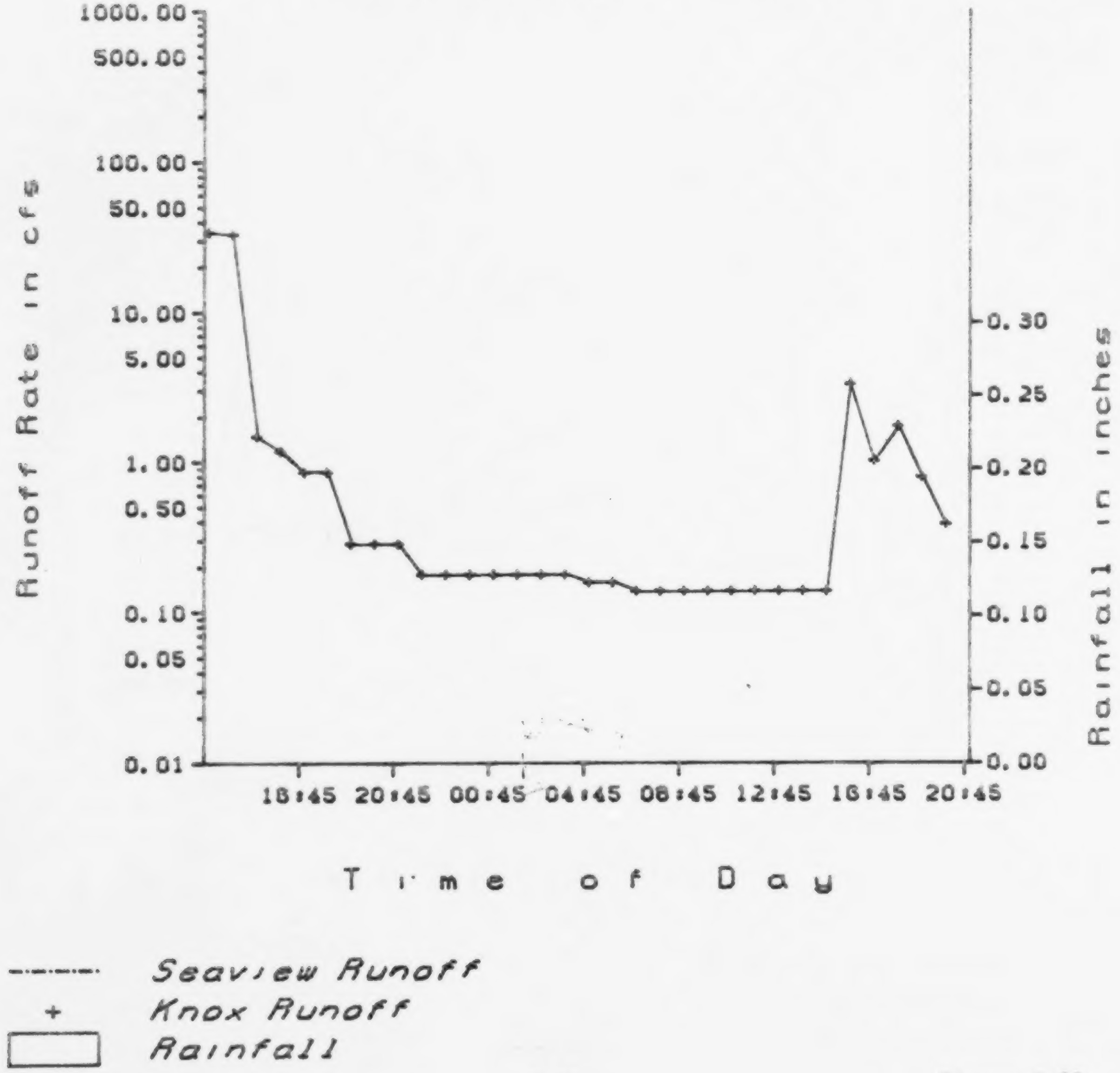


Figure E-29

San Francisco Bay Area
National Urban Runoff Project

SEAVIEW and KNOX Gaging Stations

Storm of April 22 - 23, 1980
STORM #17 - 1980

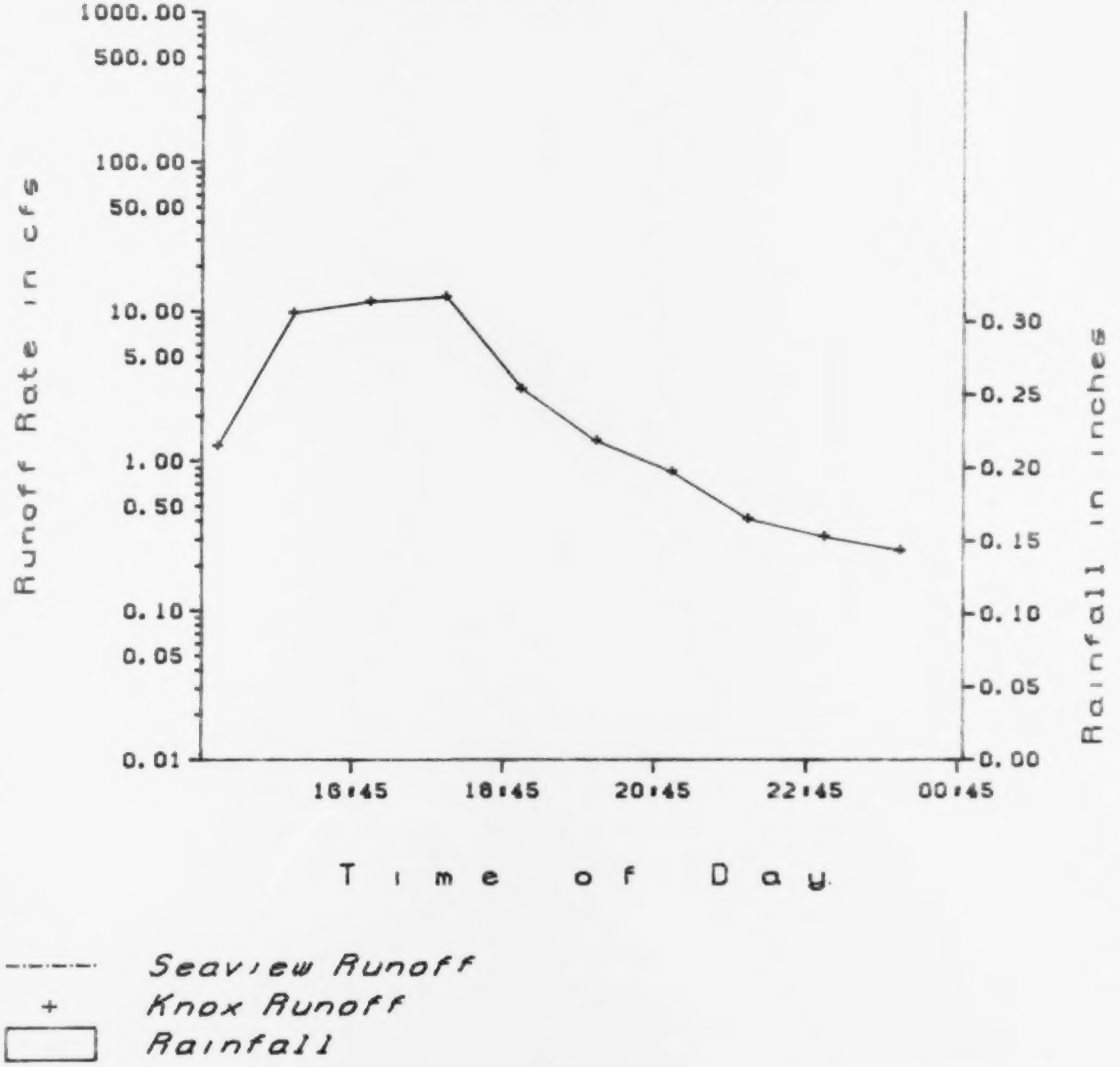


Figure E-30

APPENDIX F. COMPARATIVE STREET CLEANER TEST DATA

TABLE F-1. BASIC DATA FOR LOWER TEST AREA I

		Mechanical Performance				Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/3/79	8	671 10 mi.	506	165	25	1388 16 mi.	707	681	49
12/6	3	544 20/mi.	192	352	65	1160 21/mi.	89	1070	92
12/10	4	377 23/mi.	155	222	59	645 23/mi.	523	123	19
12/12	2	319 16 mi.	175	144	45	320 17/mi.	123	197	62
12/17	5	228 12/mi.	293	-65	-29	385 14/mi.	138	246	64

BASIC DATA FOR LOWER TEST AREA II

		Mechanical Performance				Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/7/79	2	888 38/mi.	230	659	74	909	171	738	81
12/11	4	523 16/mi.	189	333	64	1260 32/mi.	101	1161	92
12/13	2	244 60/mi.	135	108	45	296 32/mi.	96	200	68

TABLE F-2. BASIC DATA FOR MIDDLE TEST AREA I

	Mechanical Performance					Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/3/79	8	533 19/mi.	178	355	67	1080 16/mi.	431	648	60
12/6	3	174 15/mi.	137	37	21	295 13/mi.	213	82	28
12/10	4	163 19/mi.	113	50	31	183 16/mi.	151	32	18
12/12	2	176 10/mi.	121	54	31	124 13/mi.	92	32	26
12/17	5	104 9/mi.	118	-14	-13	189 16/mi.	110	79	42

BASIC DATA FOR MIDDLE TEST AREA II

	Mechanical Performance					Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/5/79	10	323 19/mi.	143	180	56	592 25/mi.	127	465	79
12/7	2	1499 11/mi.	117	33	22	242 14/mi.	64	178	74
12/11	4	104 23/mi.	92	12	12	149 16/mi.	50	99	67
12/13	2	70 29/mi.	70	0	0	121 29/mi.	42	79	65

TABLE F-3. BASIC DATA FOR UPPER TEST AREA I

		Mechanical Performance				Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/3/79	8	278 17/mi.	163	115	41	159 17/mi.	44	115	73
12/10	7	140 15/mi.	93	46	33	99 8/mi.	48	51	52
12/17	5	120 14/mi.	93	26	22	151 19/mi.	45	105	70

BASIS DATA FOR UPPER TEST AREA II

		Mechanical Performance				Regenerative Air Performance			
Date of Test	Days Since Last Cleaned	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed	Before Loading (Lbs/curb mi.) Cars/Mi.	After Loading (Lbs/curb mi.)	Lbs/curb mi. Removed	% Removed
12/5/79	10	492 7/mi.	118	374	76	349 7/mi.	298	51	15
12/7	2	276 4/mi.	144	132	48	231 4/mi.	115	116	50
12/11	4	262 6/mi.	271	-9	-4	214 2/mi.	144	70	33
12/13	2	165 14/mi.	113	51	31	199 15 mi.	115	84	42

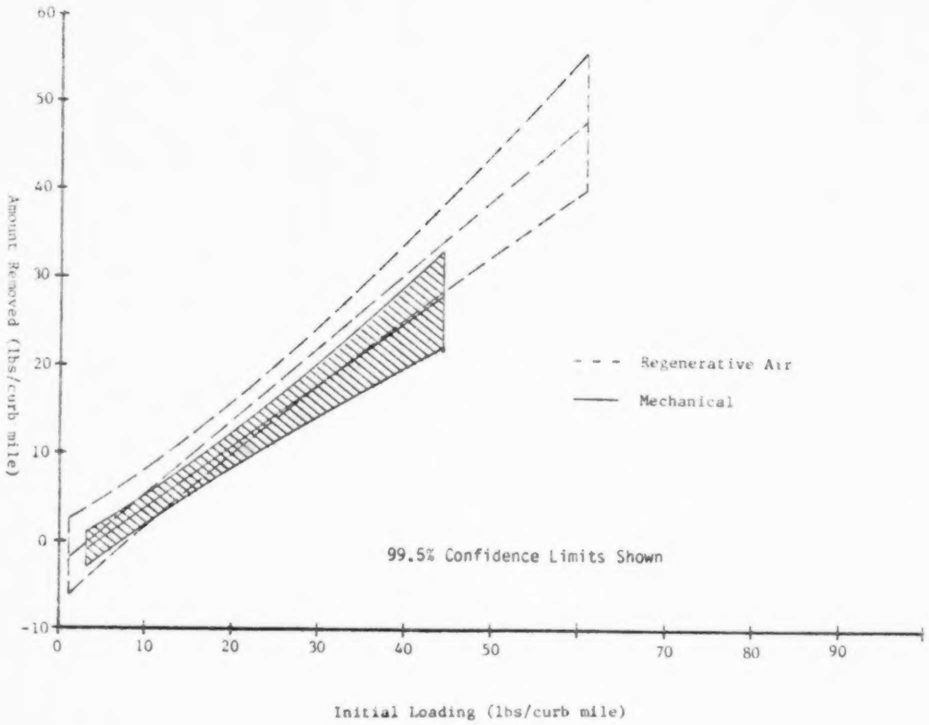


FIGURE F-1. TOTAL SOLIDS PRODUCTIVITY
(less than 45u particle size only)

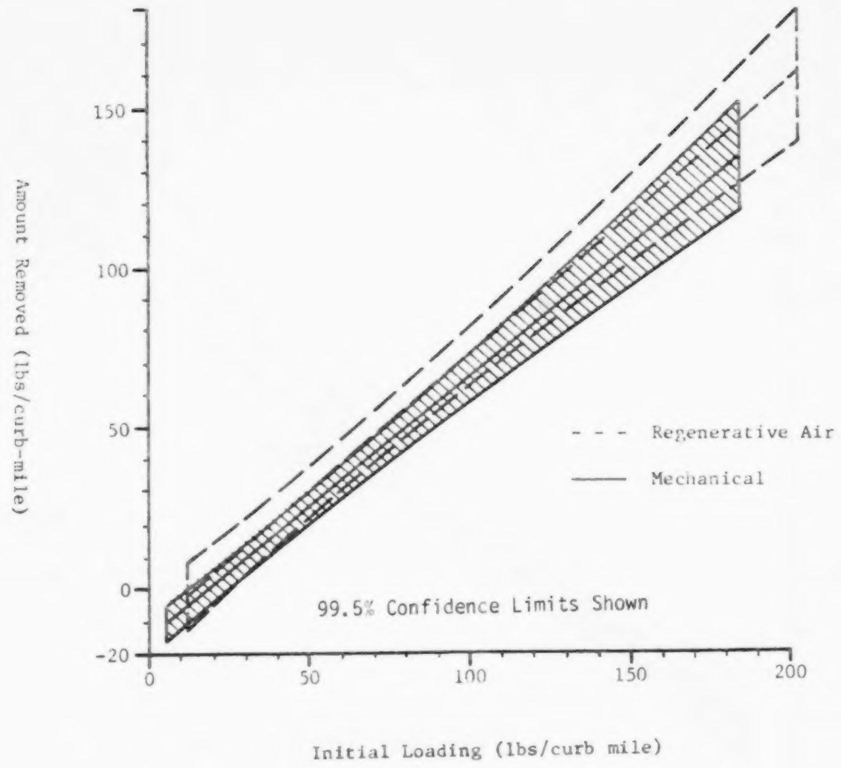


FIGURE F-2. TOTAL SOLIDS PRODUCTIVITY
(45-106u particle size only)

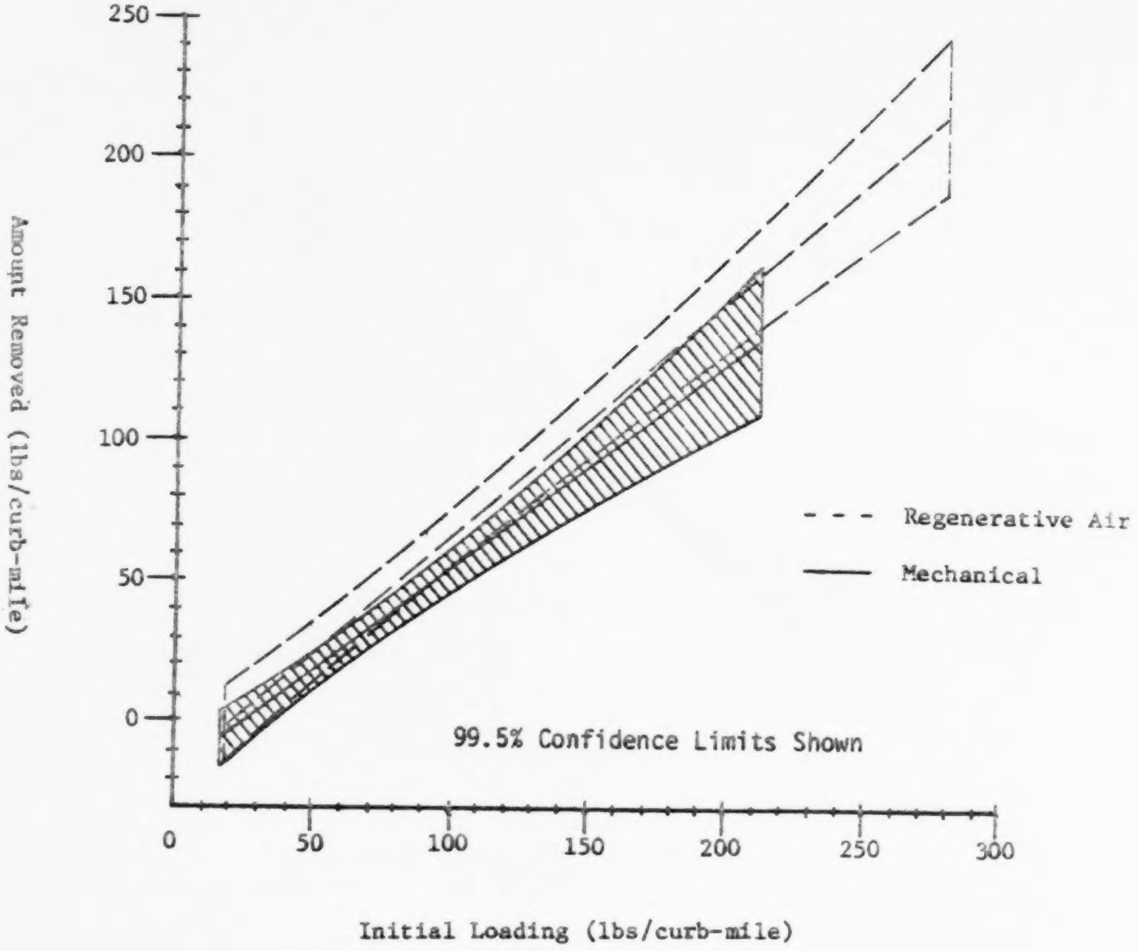


FIGURE F-3. TOTAL SOLIDS PRODUCTIVITY
(106-250u particle size only)

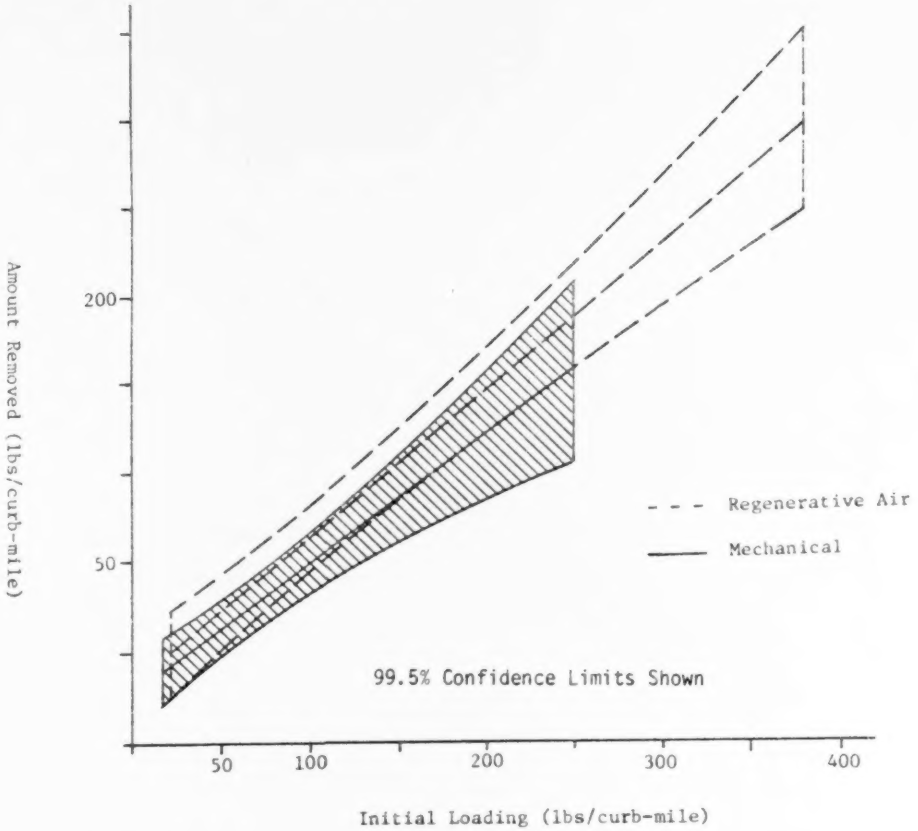


FIGURE F-4. TOTAL SOLIDS PRODUCTIVITY (250-600u particle size only)

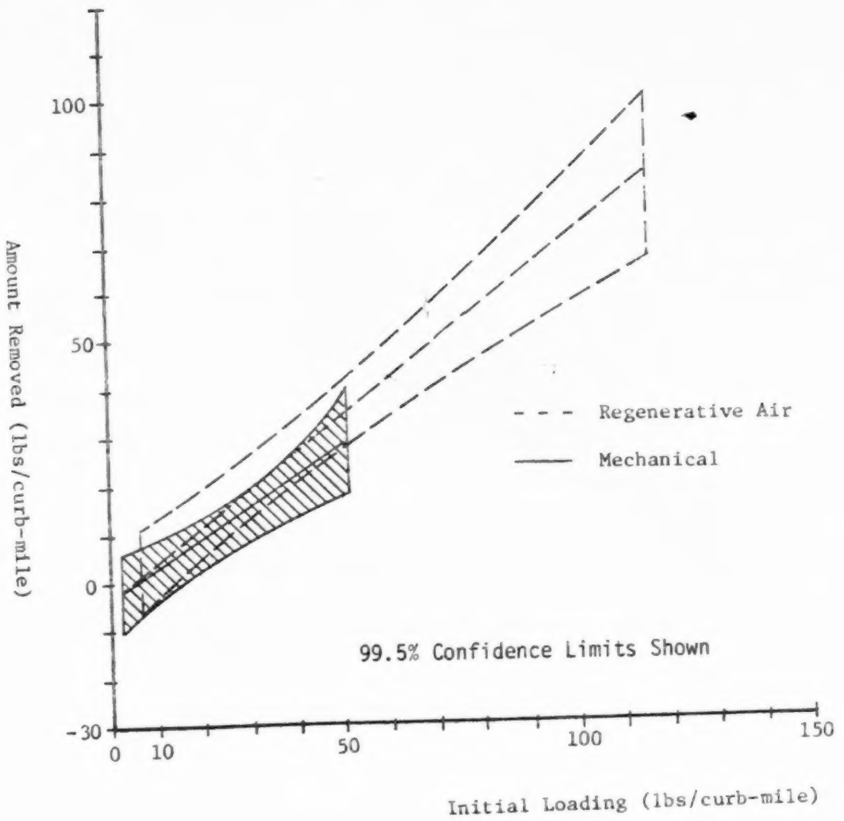


FIGURE F-5. TOTAL SOLIDS PRODUCTIVITY
(600-850u particle size only)

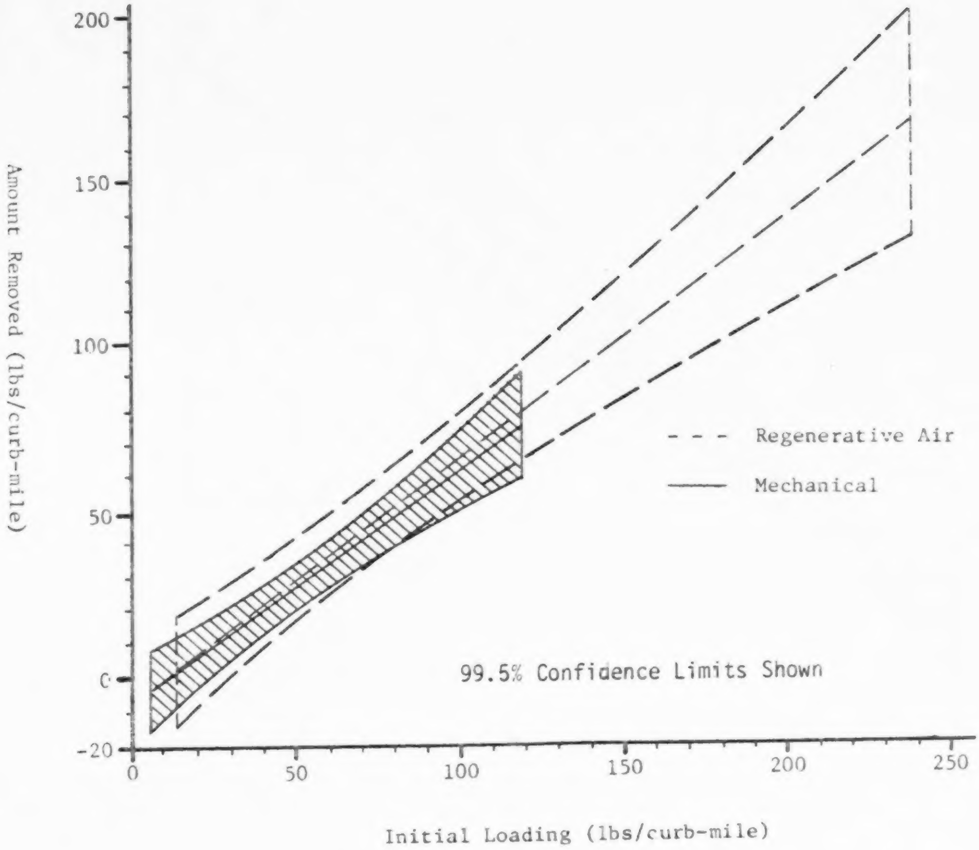


FIGURE F-6. TOTAL SOLIDS PRODUCTIVITY
(850-2000u particle size only)

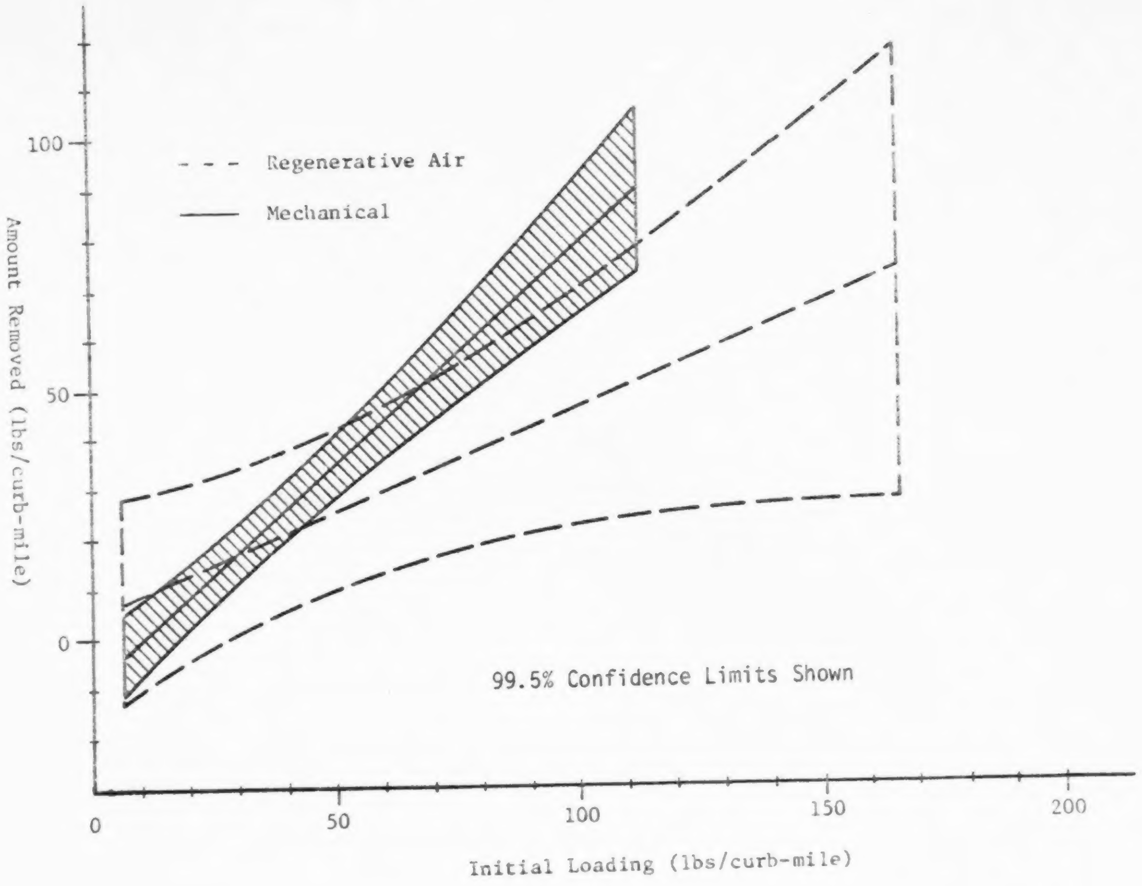


FIGURE F-7. TOTAL SOLIDS PRODUCTIVITY
(2000-6370u particle size only)

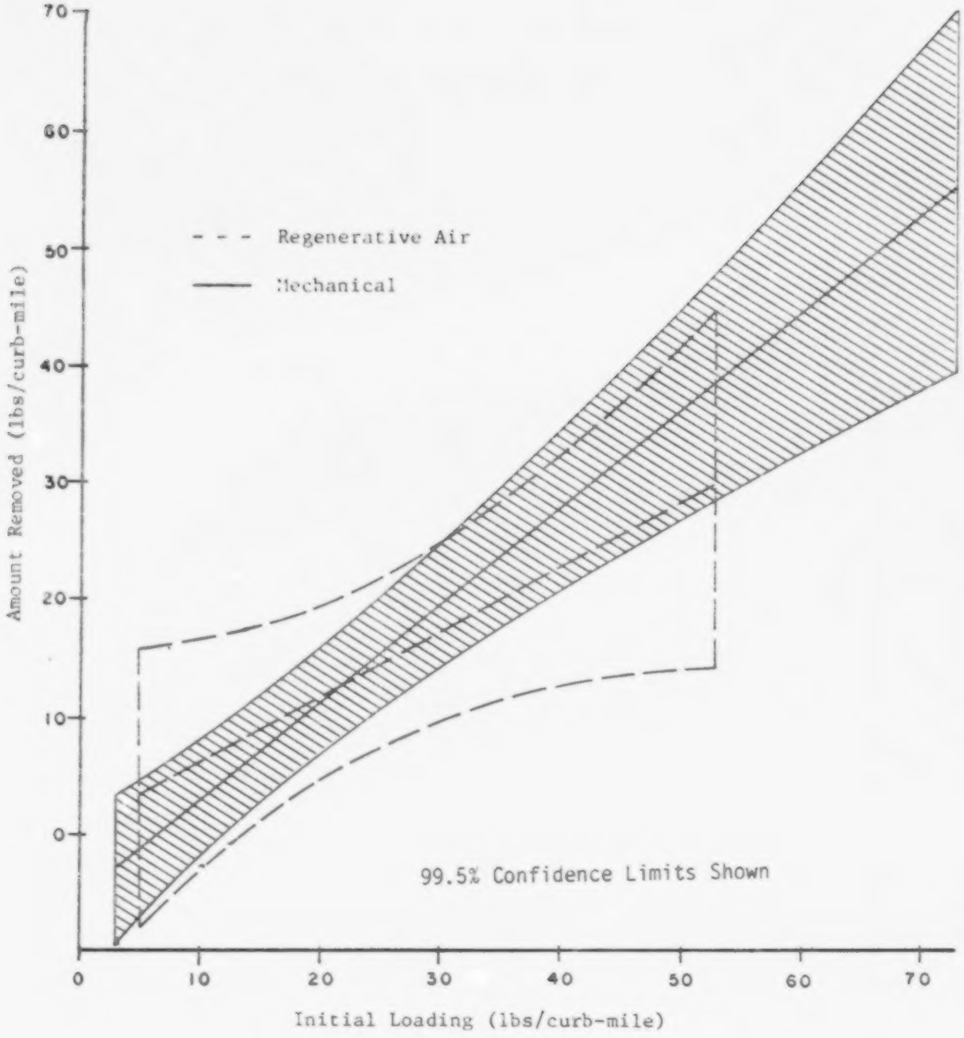


FIGURE F-8. TOTAL SOLIDS PRODUCTIVITY
(Greater than 6370u particle size only)

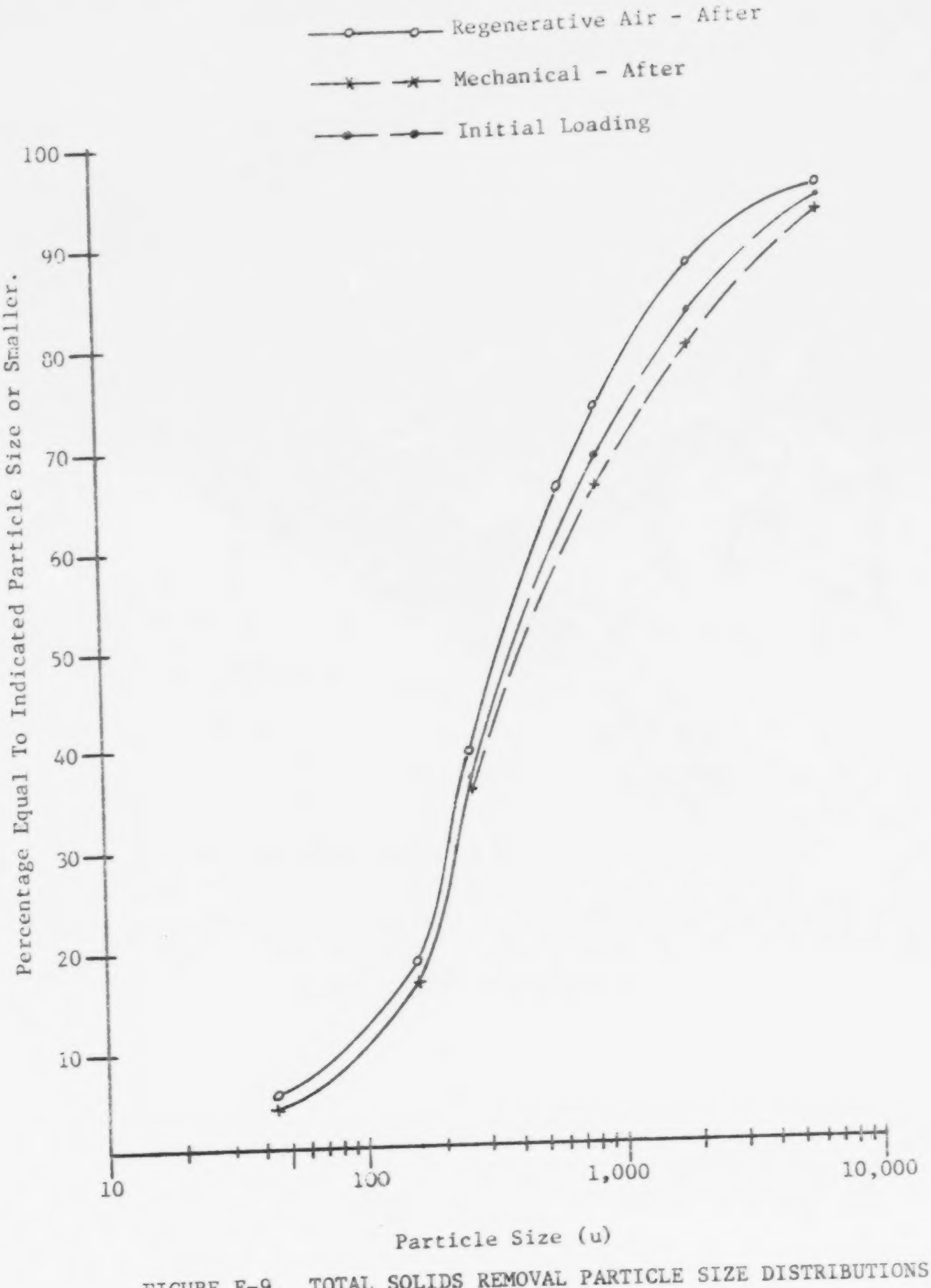


FIGURE F-9. TOTAL SOLIDS REMOVAL PARTICLE SIZE DISTRIBUTIONS (middle test area)

APPENDIX G. COSTS TO CONTROL URBAN RUNOFF

TABLE G-1. **UNIT STREET DIRT REMOVAL AND RUNOFF CONTROL COSTS FOR VARIOUS CLEANING FREQUENCIES** (Contd.)

Cleaning Frequency	Passes Per Year	Annual Costs ($/curb mi)	Annual Removal (lbs/curb mi)	Unit Removal Costs ($/lb)	Annual Runoff Yield Savings: Annual Total Watershed (lb/yr)	Annual Runoff Yield Savings: Per Curb mile (lb/curb mi)	Annual Runoff Yield Savings: Portion of runoff Controlled (%)	Annual Runoff Yield Savings: Unit Savings Cost ($/lb Saved From receiving water)	Annual Runoff Yield Savings: Ratio (lb/ Removal to lb/ saved
			Copper						
Quarterly	4	$ 60	0.053	$1,100	0	0	0	$ 0	0
Monthly	12	180	0.16	1,100	0	0	0	0	0
2X/Month	24	360	0.32	1,100	0	0	0	0	0
Weekly	52	780	0.63	1,200	0.30	0.006	1	130,000	110
2X/Week	104	1,560	1.0	1,600	2.7	0.05	3	32,000	20
3X/Week	156	2,340	1.3	1,800	5.0	0.10	7	24,000	14
5X/Week	260	3,900	1.9	2,100	6.0	0.12	8	34,000	17
10X/Week	520	7,800	2.4	3,300	6.0	0.12	8	68,000	20
			Lead						
Quarterly	4	$ 60	1.0	$ 60	0	0	0	$ 0	0
Monthly	12	180	3.1	60	0.3	0.005	<1	36,000	620
2X/Month	24	360	6.1	60	5.0	0.1	1	3,800	64
Weekly	52	780	12	65	46	0.9	9	860	13
2X/Week	104	1,560	20	78	130	2.4	26	660	8.4
3X/Week	156	2,340	26	90	180	3.4	36	680	7.6
5X/Week	260	3,900	37	110	210	4.0	43	960	9.2
10X/Week	520	7,800	46	170	210	4.0	43	1,900	11

TABLE G-2. **UNIT STREET DIRT REMOVAL AND RUNOFF CONTROL COSTS FOR VARIOUS CLEANING FREQUENCIES** (Contd.)

Total Kjeldahl Nitrogen

					Annual Runoff Yield Savings				
Cleaning Frequency	Passes Per Year	Annual Costs ($/curb mi)	Annual Removal (lbs/curb mi)	Unit Removal Costs ($/lb)	Annual Total Watershed (lb/yr)	Per Curb mile (lb/curb mi)	Portion of runoff Controlled (%)	Unit Savings Cost ($/lb Saved From receiving water)	Ratio (lb/ Removal to lb/ saved
Quarterly	4	$ 60	1.0	$ 60	0	0	0	0	0
Monthly	12	180	3.1	60	0	0	0	0	0
2X/Month	24	360	6.2	60	2.6	0.05	<1	$7,200	120
Weekly	52	780	12	65	15	0.30	1	2,600	42
2X/Week	104	1,560	20	78	42	0.80	2	2,000	26
3X/Week	156	2,340	26	90	60	1.2	3	2,000	22
5X/Week	260	3,900	37	110	65	1.3	3	3,200	30
10X/Week	520	7,800	47	170	65	1.3	3	6,200	38

Arsenic

Quarterly	4	$ 60	0.01	$ 6,000	0	0	0	0	0
Monthly	12	180	0.03	6,000	0	0	0	0	0
2X/Month	24	360	0.06	6,000	0.05	0.001	1	$360,000	60
Weekly	52	780	0.11	7,100	0.35	0.007	6	110,000	16
2X/Week	104	1,560	0.18	8,700	0.85	0.017	15	94,000	11
3X/Week	156	2,340	0.24	9,800	1.2	0.023	21	100,000	10
5X/Week	260	3,900	0.34	11,000	1.3	0.024	22	160,000	14
10X/Week	520	7,800	0.42	19,000	1.3	0.024	22	330,000	18

TABLE G-3. UNIT STREET DIRT REMOVAL AND RUNOFF CONTROL COSTS FOR VARIOUS CLEANING FREQUENCIES (Contd.)

TOTAL PHOSPHOROUS

					Annual Runoff Yield Savings				
Cleaning Frequency	Passes Per Year	Annual Costs ($/curb mi)	Annual Removal (lbs/curb mi)	Unit Removal Costs ($/lb)	Annual Total Watershed (lb/yr)	Per Curb mile (lb/curb mi)	Portion of runoff Controlled (%)	Unit Savings Cost ($/lb Saved From receiving water)	Ratio (lb/ Removal to lb/ saved
Quarterly	4	$ 60	0.32	$190	19	0.36	3	$ 170	0.9
Monthly	12	180	0.94	190	20	0.38	3	480	2.6
2X/Month	24	360	1.9	190	21	0.40	3	900	4.8
Weekly	52	780	3.8	210	28	0.55	4	1,400	7.0
2X/Week	104	1,560	6.1	260	43	0.90	7	1,700	6.8
3X/Week	156	2,340	8.0	290	60	1.2	10	2,000	6.6
5X/Week	260	3,900	11	350	60	1.2	10	3,200	9.2
10X/Week	520	7,800	14	560	60	1.2	10	6,600	12
ORTHO PHOSPHATES									
Quarterly	4	$ 60	0.020	$3,000	0.16	0.003	<<1	$20,000	6.6
Monthly	12	180	0.060	3,000	0.34	0.007	<<1	28,000	9.2
2X/Month	24	360	0.12	3,000	0.55	0.011	<<1	34.000	11
Weekly	52	780	0.24	3,300	1.3	0.025	<1	32,000	9.6
2X/Week	104	1,560	0.39	4,000	2.3	0.044	<1	36,000	9.0
3X/Week	156	2.340	0.51	4,600	3.0	0.055	<1	42,000	9.2
5X/Week	260	3,900	0.72	5,400	3.2	0.060	<1	66,000	12
10X/Week	520	7,800	0.90	8,700	3.2	0.060	<1	130,000	15

TABLE G-4. **UNIT STREET DIRT REMOVAL AND RUNOFF CONTROL COSTS FOR VARIOUS CLEANING FREQUENCIES** (Conclusion)

			Zinc						
					Annual Runoff Yield Savings				
Cleaning Frequency	Passes Per Year	Annual Costs ($/curb mi)	Annual Removal (lbs/curb mi)	Unit Removal Costs ($/lb)	Annual Total Watershed (lb/yr)	Per Curb mile (lb/curb mi)	Portion of runoff Controlled (%)	Unit Savings Cost ($/lb Saved From receiving water)	Ratio (lb/ Removal to lb/ saved
Quarterly	4	$ 60	0.16	370	8.5	0.16	2	$ 380	1.0
Monthly	12	180	0.49	370	9.5	0.19	2	980	2.6
2X/Month	24	360	0.98	370	10	0.20	3	1,800	5.0
Weekly	52	780	2.0	390	17	0.33	4	2,400	6.0
2X/Week	104	1560	3.2	490	30	0.55	8	2,800	5.8
3X/Week	156	2340	4.2	560	38	0.75	10	3,200	5.6
5X/Week	260	3900	5.9	660	40	0.80	10	4,800	7.4
10X/Week	520	7800	7.4	1100	40	0.80	10	9,800	9.2

APPENDIX H

RECOMMENDED SAMPLE COLLECTION, FIELD SAMPLE PREPARATION, AND LABORATORY ANALYSES FOR ASBESTOS FIBER DETERMINATIONS IN WATER.

These recommended procedures are based on several interim procedures published by the EPA and other researchers (Anderson and Long 1978; Garber 1976; Manalan 1976; and McCrone 1977). They are therefore subject to review and revision and should be confirmed before any analytical programs are started. This appendix stresses the field procedures and briefly outlines the laboratory steps in TEM analyses. It also lists the typical errors that may occur with TEM.

SAMPLE COLLECTION

Generally, basic principles of water sampling are applicable for sampling water for asbestos analyses. However, there are some physical characteristics of asbestos that may require special consideration. These characteristics are the wide distribution of asbestos fiber in water (usually ranging from 0.1 to 20 microns or more) and their typically low water concentrations. Because of their range in size, the asbestos fibers are easily stratified in a water column. A turbulent water flow, however, would result in a well-mixed body of water with the asbestos samples more evenly distributed. Therefore, care should be taken in selecting sampling locations that have well-mixed, turbulent flows, or a depth-integrated sampling procedure should be used. Alternatively, individual samples can be collected at the surface and at various depths of the water for discrete analyses. If the flows in the water body change rapidly with time, then a long averaging period must be used in sample collection instead of grab samples. Therefore, all three spacial dimensions, in addition to the time dimensions, must be considered in conducting an asbestos water sampling program.

The U.S. Environmental Protection Agency (Anderson and Long 1978) specifies that a clean polyethylene screw cap bottle capable of holding at least one liter should be used for sample shipment. The bottle, after being well cleaned in the laboratory before being taken into the field, should be rinsed at least two times with the sample water prior to sampling. It is important to note that glass containers are not suitable for asbestos sample shipment.

A fairly rigorous cleaning procedure is necessary for the sampling containers, field sample-handling glassware, and laboratory equipment. The EPA specifies that the glassware be rinsed initially three times with distilled water, followed by an ultrasonic bath with an Alconox-water solution. After the ultrasonic cleaning, the glassware is then rinsed three more times with distilled water followed by three more rinses with deionized water that has been filtered through a 0.1 micron Nuclepor filter. The glassware is then dried in an asbestos-free oven and the openings are sealed with parafilm. This washing procedure should be conducted on the sample collection polyethylene bottles before they are taken into the field. As noted above, the bottles should be thoroughly rinsed with sample water before the material is sampled. However, any glassware necessary for field filtration should be initially cleaned using this rigorous cleaning procedure. Between sampling locations in the field, the field glassware should be washed and rinsed using the sample water.

At least one liter of water is required for each sample, but the sample container should not be filled completely. Two samples should be obtained from each location to allow for possible reanalyses, because sensitive laboratory procedures are dependent upon the actual asbestos concentrations.

No preservatives are to be used during sampling and sample handling. Acids definitely should not be used. If a sample cannot be filtered in the analytical laboratory within 48 hours, then care should be taken to keep the filled sample bottles in the dark to inhibit bacterial growth. The samples must also be kept from freezing, which may break down the asbestos fibers and result in higher fiber counts. Therefore, the samples should be maintained at temperatures above freezing.

If the samples cannot be delivered to the laboratory within a short period of time, or if transporting a large volume of samples is a problem, serious consideration should be given to filtering the samples in the field upon collection. However, even if field filtration is to be used, some water (one liter if possible) should still be retained and delivered to the lab for backup analyses. Backup samples are especially important for asbestos analyses because of the complexity of the laboratory procedure. Prepared samples have to be rejected if the sampling filter grids are too heavily loaded with fibers to perform accurate counting. If the fiber distribution is noticeably uneven, or if there is too much organic or inorganic debris obscuring the fibers, the samples must also be reprepared. In addition, if the grid squares on the filter are mostly broken, then new sample preparation is required.

FILTERING THE ASBESTOS SAMPLES IN THE FIELD

As mentioned previously, if the samples cannot be delivered to the laboratory in a reasonable period of time, or if shipping large volumes of water is undesirable, then filtering the samples in the field may be necessary. Field filtration, if carefully done, may be used as a preliminary step in sample analyses. However, it may also be considered a method to condense the particulates in the samples (including the asbestos fibers) for transportation to the laboratory. The dried filters can then be ashed to remove the organic material and resuspended in a solution for more precise filtration in the laboratory. However, all filtration should be done with the assumption that it is a very critical step and will not be repeated in the laboratory because of contamination potential and the possibility of losing some of the fibers through sloppy filtration techniques.

The volume of sample to be filtered usually ranges from 50 to 500 milliliters. A very faint stain of particulates should be observed on the filter media after filtration. The maximum loading that can be tolerated is about 200 micrograms of solids on 47 millimeter standard diameter filters. About 50 micrograms is optimum. If the total solids content of the sample is known, an estimate of the maximum volume tolerable can be obtained. If the sample has a high solids content, and less than 50 milliliters is required for filtration, the sample should be diluted with filtered distilled water so a minimum total of 50 milliliters of water is filtered. This is necessary to ensure a uniform distribution of fibers and particulates on the filter.

As mentioned previously, the filtration funnel assembly (a Millipore glass funnel filtration system containing a glass frit support) must be scrupulously cleaned before each filtration. As described previously, an initial cleaning of the equipment is necessary after storage. However, the use of sample water to clean the glassware in the field before the sample is taken should be adequate if appropriate detergents and many rinses are used. A second filtration unit should be carried to prepare filtered sample water that can be used to rinse everything before the sample is filtered.

The standard filter procedure includes the use of a 0.1 micron Nuclepore filter backed with a 0.45 micron Millipore filter. These filters are mounted in a Millipore glass funnel filtration system. However, cellulose acetate-type filters, such as the Millipore Type MF or the Gelman GN-6 Metricel filters, have better sample retention characteristics during shipping than do poly-carbonate filters of the Nuclepore type. Therefore, final selection of a specific filter type is important and will have to be made after the specifics of the sampling program are known.

A simple hand-operated vacuum pump can be used, in conjunction with the Millipore glass funnel filtration system, to draw the sample through the filter. The water sample must be vigorously agitated in its container and a known quantity of sample is immediately withdrawn and placed in the 47 millimeter diameter funnel. The vacuum must be sufficient for filtration, but gentle enough to avoid the formation of a vortex. If the asbestos concentrations and total solid concentrations of the sample are unknown, then exactly 500 milliliters of a well-mixed sample should be poured from a 500 millimeter graduated cylinder into the vacuum filtration apparatus. If the resulting filter appears heavily coated or discolored after filtering, it is recommended that another filter be prepared in the same manner, but this time using only 200 or 100 milliliters of sample. All filter samples prepared should be retained and sent to the laboratory and carefully noted as to sampling location, sampling time, and sample volume. Do not add more water after the filtration has started and do not rinse the sides of the funnel.

After filtering, the funnel assembly is disassembled and the filter is removed with clean forceps and placed in a covered petri dish for drying and transportation. Millipore supplies special low profile petri dishes for 47 millimeter filters upon which various sample information can be written. After a day of field collection, the covers of the petri dishes should be slightly loosened to allow the filters to air dry before shipment to the laboratory. However, if insufficient time or facilities are available for sample drying, then the damp filter, placed in the covered petri dish, should be wrapped in a light-tight package and delivered to the laboratory as soon as possible.

If possible, three filtrations should be conducted for each sample, with the quantity of sample passed through each filter, each in different magnitudes of volume (such as 50, 500, and 5,000 milliliters).

If the water to be sampled for asbestos fibers has a large quantity of biological material (such as algae), the biological material may plug the membrane filter before a suitable number of fibers have been deposited. In this case, the sample can be delivered to the laboratory unfiltered (in a darkened bottle) or the sample can be treated with sodium hypochloride to clear the water before filtering. However, a preferable procedure is to attempt to filter the total sample and have the analytical laboratory ash the organic matter before resuspending and refiltering the remaining inorganic material.

The EPA (1978) summarized reported asbestos concentrations in freshwater drinking supplies found in Canada and the United States. Typical asbestos concentrations were 100 thousand to about 200 million fibers per liter for contaminated water bodies. Most of the asbestos is of the chrysotile variety. Because of the lack of data, the EPA has not established any aquatic life criteria for asbestos. They are, however, considering interim target concentrations ranging from 3,000 to 300,000 fibers per liter for drinking water sources. These rough values may be used in estimating starting points for field filtration.

RECOMMENDED LABORATORY ANALYTICAL PROCEDURES

Several laboratory procedures are currently used to analyze asbestos fiber concentrations in water. Transmission electron microscopy (TEM) is the most useful procedure for the detection and identification of asbestos fibers smaller than the resolving power limit of the light microscope. This is usually necessary for water because of the smaller sizes of asbestos particles typically found in water as compared to other media (such as bulk insulation) that may be sampled for asbestos. Quantitative procedures are available so that the number, size, and identity of the asbestos fibers per unit volume can be accurately determined. Identification by TEM depends upon selected area electron diffraction (SAED) procedures. There is no better procedure than TEM/SAED for analysis of samples containing subpicogram particles. TEM/SAED is the accepted water quality analysis procedure for drinking water supplies, as established by the EPA (Anderson and Long 1978).

Polarized light microscopy (PLM) is a procedure using a light microscope and has a high sensitivity and is extremely rapid. Although it is limited to fairly large fibers, it is the only procedure that can identify individual amphibole asbestos fiber types. When PLM is used with dispersion staining

(DS), it is very effective because it is the only analytical procedure that depends upon the unique optical crystallographic properties of the various crystal phases of the samples. This helps to differentiate the different fiber types from other fibers likely to be present in the sample.

X-ray diffraction (XRD) is also a useful method since it can be made quantitative. However, it cannot tell size or shape and is not very sensitive. It is, however, an effective supplemental technique.

Because TEM/SAED is the recommended analytical procedure for drinking water supplies, the following paragraphs briefly describe the procedure. This method is applicable to drinking water and water supplies that are typically not grossly contaminated with other particulate material. When large quantities of other particulates are present, then special separation and ashing procedures may be necessary. Flotation of the asbestos fiber off a filtered mat containing other particulates will tend to decrease the obscuring number of particulates under microscopic examination. In addition, ashing at a high temperature can volatilize the organic material, which may also obscure the sample. Both of these procedures tend to decrease the total number of asbestos fibers observed, resulting in a final concentration of fibers lower than actually present.

Under favorable circumstances, the detection limit of TEM/SAED is about 0.1 million fibers per liter, and about 0.1 nanograms per liter.

A sample is filtered through a 0.45 micron membrane filter which is of sufficient pore size to trap the asbestos fibers. This recommended procedure uses a 0.45 micron filter, in contrast to the 0.1 micron filter previously described for field sampling. Again, the selection of the type and size of filter for field filtration is determined by the project objectives. A small portion of the filter, with the deposited fibers, is placed on an electron microscope grid and the filter material is removed by gentle solution in an organic solvent. The material remaining on the electron microscope grid is coated and examined in a transmission electron microscope at high magnification (20,000 power). The asbestos fibers are identified by their morphology and electron defraction pattern. Their length and width are also measured. The concentration in millions of fibers per liter is calculated from the number of fibers counted, the amount of filtered water used, and the ratio of the total filtered area to sampled filter area. The mass of asbestos fibers per liter is calculated, using an assumed density and the measured volume of the fibers.

Several interferences may also occur with TEM/SAED. The fibers may be misidentified because of unfavorable fiber orientation and fiber sizes. Therefore, the results may be reported lower than the actual count. In addition, if there are large amounts of organic or amorphous inorganic fibers present, some small asbestos fibers may not be observed because they are obscured. This will also result in a lower count. In addition, the sample may be contaminated by sampling or handling. This would result in more fibers being counted.

Within a single laboratory, using the same analytical procedures in sample handling and analytical techniques, a 25 to 35 percent error is likely to occur with fiber concentrations of 10 to 30 million fibers per liter. The precision will decrease approximately proportional to the square root of the number of fibers counted. When the same samples are sent to different laboratories, the EPA (Anderson and Long 1978) reported errors of about 35 to 65 percent. These error values are expressed as relative standard deviations and are difficult to measure because of the problems of obtaining duplicable reference samples. However, reference samples are available and should be routinely analyzed with the samples. At a count of 1 million fibers per liter, the calculated results should be within a factor of 10 of the actual asbestos fiber content. It is generally believed that TEM/SAED results are biased on the low side.

APPENDIX I

LABORATORY ASBESTOS RESULTS

TABLE I-1. RESULTS OF ASBESTOS SCREENING TEST FOR MISC. PAVED AREA, ROOFTOP PARTICULATE SAMPLES AND CASTRO VALLEY CREEK WATER SAMPLES

	Asbestos Observed by:		Other Material Present, Observed by:	
Sample Description	Optical Methods	TEM/ SAED	Optical Methods	TEM/SAED
Paved School Playground	no	light	rtm*	light debris
Paved Parking Lots	no	light	rtm	light-mod. debris
Concrete Driveways	one fiber	no	rtm	mod. debris, light non-asbestos fiber
Rooftop-asphalt <1 yr. old	no	light	rfm & plant material	----
Rooftop-asphalt >1 yr. old	no	light	rfm & plant material	----
Rooftop-wooden, 20 yrs. old	one fiber	light	rfm & plant material	----
Rooftop-Commercial composite of asph., wood, tar & gravel roofs	no	light	rfm & plant material	----
Runoff-Knox 11/3/79	no	trace	---	other fibers, clay-like material & a few diatom fragments
Runoff-Knox 11/17/79	no	no	---	granular debris, few diatoms
Runoff-Seaview 11/30/79	no	no	---	organic debris
Runoff-Knox 11/30/79	no	no	---	very fine granular debris
Runoff-Knox 12/21/79	no	no	---	debris, some non-asbestos thin fibers
Runoff-Seaview 12/26/79	no	no	---	clay-like debris, thin non-asbestos fibers

TABLE I-1. (concluded.)

Sample Description	Asbestos Observed by: Optical Methods	Asbestos Observed by: TEM/ SAED	Other Material Present, Observed by: Optical Methods	Other Material Present, Observed by: TEM/SAED
Runoff-Knox 12/26/79	no	no	---	clay-like debris, numerous non-asbestos fine fibers
Runoff-Knox 12/31/79	no	no	---	granular debris (organics), few non-asbestos fibers
Runoff-Knox 2/25/80	no	no	---	many non-asbestos fibers (<0.5m in length)
Runoff-Seaview 2/25/80	no	no	---	" "
Runoff-Knox 2/28/80	no	no	---	" "
Runoff-Seaview 2/28/80	no	no	---	" "
Runoff-Seaview 3/4/80	no	no	---	some non-asbestos fibers & large particulates
Runoff-Knox 3/4/80	no	light	---	
Runoff-Knox 3/7/80	no	trace	---	---
Runoff-Seaview 3/7/80	no	light	---	---
Runoff-Knox 4/23/80	no	light	rfm, diatoms	light debris, light diatoms

*rfm = rock-forming minerals

TABLE I-2. RESULTS OF ASBESTOS SCREENING TESTS FOR UNPAVED AREA AND CREEK SEDIMENT SAMPLES

	Asbestos Observed by:		Other Material Present, Observed by:	
Sample Description	Optical Methods	TEM/SAED	Optical Methods	TEM/SAED
Rural Vacant Lot 1	no	lt.-mod.	rfm	moderate debris
Rural Vacant Lot 2	no	no	rfm	mod.-heavy debris, mod. non-asbestos
Rural Vacant Lot 3	no	light	rfm	lt.-mod. debris, light diatoms, mod. non-asbestos fibers
Rural Vacant Lot 4	no	light	rfm	mod. debris
Urban Vacant Lot 1	no	no	rfm	lt. debris, some non-asbestos fibers
Urban Vacant Lot 2	no	lt.-mod.	rfm	light debris
Urban Const. Area 1	no	light	light clay	lt. debris, lt. non-asbestos fibers
Urban Const. Area 2	no	no	rfm	mod. debris, lt. non-asbestos fibers
Unpaved driveways	no	no	rfm	lt. mod. debris, lt. non-asbestos fibers
Unpaved parking lots	no	mod.	rfm	moderate debris
Residential lawns	no	light	rfm	moderate debris
School turf	no	light	heavy wood fibers	lt. mod. debris
Residential gardens	no	light	rfm	moderate debris
Landscaped park	no	light	light diatoms	light debris

TABLE I-2. (concluded.)

Sample Description	Asbestos Observed by: Optical Methods	Asbestos Observed by: TEM/SAED	Other Material Present, Observed by: Optical Methods	Other Material Present, Observed by: TEM/SAED
Creek Sediment:				
Rural-above Seaview	no	light	rfm	moderate debris
Rural-above Seaview confl.	no	lt.-mod.	light algae	moderate debris
Rural-At Seaview confl.	light	light	light diatoms, algae	lt. diatoms, mod. non-asbestos fibers
Rural-At Seaview gage	no	no	rfm	light debris
Urban-Heyer St.	no	light	rfm	mod. debris
Urban-Berding St.	no	no	light diatoms	mod. debris, lt. large diatoms, lt. non-asbestos fibers
Urban-Knox gage	no	light	light diatoms	mod.-heavy debris, lt. large diatoms
Urban-Chabot confl.	no	light	mod. diatoms	mod.-heavy debris

TABLE I-3. RESULTS OF ASBESTOS SCREENING TESTS FOR FIRST YEAR SUMMER STREET SURFACE PARTICULATE SAMPLES (6/13/79 - 8/9/79)

Sample Description	Asbestos Observed by: Optical Methods	Asbestos Observed by: TEM/SAED	Other Material Present, Observed by: Optical Methods	Other Material Present, Observed by: TEM/SAED
Lower Area Streets				
2000-6370u size	no	none	rfm	mod. particulate matter
850-2000u	no	none	rfm	mod.-heavy debris
600-850u	no	light	rfm	lt.-mod. particulate matter
250-600u	no	mod.	rfm	heavy debris
106-250u	no	light	rfm, plant fibers	lt.-mod. prticulate matter (some amosite asbestos)
45-106u	no	light	glass	mod. particulate matter
<45u	no	light	rfm	lt. non-asbestos
Middle Area Streets				
2000-6370u size	no	light	rfm	diatoms, mod. debris
850-2000u	no	trace	rfm	mod. particulate matter
600-850u	no	lt.- mod.	rfm	diatoms, mod. debris, non-asbestos fibers
250-600u	no	light	rfm	mod. debris
106-250u	no	mod.	rfm, heavy plant material & fibers	mod. fine granular material
45-106u	no	none	rfm, plant & glass fibers	mod.-heavy debris
<45u	no	none	rfm, plant fibers	diatoms, non-asbestos fibers, mod. particulate matter

TABLE I-3. (concluded.)

Sample Description	Asbestos Observed by: Optical Methods	TEM/ SAED	Other Material Present, Observed by: Optical Methods	TEM/SAED
Upper Area Streets 2000-6370u size	no	light	rfm	mod.-heavy debris
850-2000u	no	lt.-mod.	rfm	mod. debris
600-850u	no	light	rfm	mod. debris
250-600u	no	light	rfm	lt. debris (some amosite)
106-250u	no	light	rfm, glass fibers	lt.-mod. debris
45-106u	no	light	rfm, glass fibers	lt.-mod. debris
<45u	no	none	rfm	mod. debris

TABLE I-4. RESULTS OF ASBESTOS SCREENING TESTS FOR SECOND YEAR STREET SURFACE PARTICULATE SAMPLES (9/6/79 - 3/13/80)

Sample Description	Asbestos Observed by: Optical Methods	TEM/SAED	Other Material Present, Observed by: Optical Methods	TEM/SAED
Fall (9/6-10/30/79)				
2000-6370u size	no	mod.	rfm	mod. debris
850-2000u	no	light	rfm	mod.-heavy debris, mod. non-asbestos fibers
600-850u	no	light	rfm	light debris
250-600u	no	light	rfm, plant material	mod. debris, light diatoms
106-250u	no	very lt.	rfm, plant fibers	mod.-heavy debris, lt. non-asbestos fibers
45-106u	no	very lt.	rfm	lt. granular particles, lt. non-asbestos fibers
<45u	no	very lt.	rfm, plant fibers	mod. particulate matter, light non-asbestos fibers
Fall (11/5-12/26/79)				
2000-6370u size	no	trace	rfm	mod. debris, mod. non-asbestos fibers
850-2000u	no	none	rfm	mod. debris
600-850u	no	none	rfm	mod. particulate matter, lt. non-asbestos fibers
250-600u	no	none	rfm, polymer fibers	mod.-heavy debris
106-250u	no	very lt.	rfm, glass & plant fibers	mod.-heavy debris, lt. non-asbestos fibers

TABLE I-4. (concluded.)

	Asbestos Observed by:		Other Material Present, Observed by:	
Sample Description	Optical Methods	TEM/ SAED	Optical Methods	TEM/SAED
Fall (cont.)				
45-106u	no	light	rfm, glass & cellulose fibers	hvy. debris, lt. diatoms, lt. non-asbes. fibers
<45u	no	very lt.	rfm	lt.-mod. debris, lt. non-asbestos fibers
Winter (1/13-3/13/80)				
2000-6370u size	no	trace	rfm	mod. debris (trace amount amosite)
850-2000u	no	light	rfm, polymer fibers	mod. particulate matter
600-850u	no	light	rfm	mod. debris
250-600u	no	very lt.	rfm	mod.-heavy debris
106-250u	no	light	rfm, plant & glass	mod.-heavy debris, some diatoms
45-106u	no	light	rfm	mod. debris, lt. non-asbestos fibers
<45u	no	light	rfm	mod.-heavy debris, diatoms, & non-asbestos fibers

TABLE I-5. RESULTS OF TEM/SAED QUANTITATIVE ASBESTOS ANALYSES ON SELECTED SAMPLES

Sample Description	Total Asbestos Fiber Conc. (10^6 fiber/gram or 10^6 fiber/liter)	Chrysotile Fiber Conc. (10^6 fiber/gram or 10^6 fiber/liter)	Amphibole Fiber Conc. (10^6 fiber/gram or 10^6 fiber/liter)
Runoff Knox 11/3/79	22.1	22.1	<0.3
Runoff Knox 3/4/80	114	111	2.7
Runoff Seaview 3/7/80	152	152	<15
Runoff Knox 3/7/80	319	289	30.4
Runoff Knox 4/23/80	7.6	7.6	<0.3
Street Dirt Lower 250-600u size	831	825	6
Street Dirt Middle 600-850u size	431	413	18
Street Dirt Middle 106-250u size	1300	1270	23
Street Dirt Upper 850-2000u size	385	363	22
Street Dirt Fall 2000-6370u size	73	73	<1.1
Paved School Playground	830	830	<6.8
Paved Parking Lot	55	54	1.2
Unpaved Parking Lot	54	54	<1.9
Rural Vacant Lot - 1	77	77	<1.8
Urban Vacant Lot - 2	110	110	<7.9
School Turf	730	730	<16
Rural Creek Sediment Seaview confl.	230	230	<12
Urban Creek Sediment Heyer	39	39	<4.8
Rooftop asphalt shingles >1 yr old	1900	1900	<20
Rooftop wooden shingles/shakes, 20 yrs. old	303	303	<4
Rooftop asphalt shingles <1 yr old	1200	1200	<21
Rooftop - commercial composite of gravel, tar, wood & asphalt roofs	670	670	<14

TABLE I-5. (continued.)

Sample Description	Total Asbestos Fiber Mass (ug asbestos/gram sample or ug/liter)	Median Particle Length (Microns)	Median Particle Width (Microns)
Runoff Knox 11/3/79	0.6	1.16	0.09
Runoff Knox 3/4/80	3.1	1.39	0.08
Runoff Seaview 3/7/80	3.2	1.28	0.09
Runoff Knox 3/7/80	11.2	1.30	0.08
Runoff Knox 4/23/80	5.9	1.74	0.08
Street Dirt Lower 250-600u size	13.6	0.98	0.07
Street Dirt Middle 600-850u size	26	0.90	0.07
Street Dirt Middle 106-250u size	16	0.73	0.07
Street Dirt Upper 850-2000u size	31	0.89	0.07
Street Dirt Fall 2000-6370u size	1.2	1.70	0.07
Paved School Playground	16	1.26	0.07
Paved Parking Lot	1.8	1.24	0.07
Unpaved Parking Lot	1.8	1.49	0.08
Rural Vacant Lot - 1	1.1	1.33	0.07
Urban Vacant Lot - 2	1.2	1.17	0.07
School Turf	10	0.96	0.07
Rural Creek Sediment Seaview confl.	2.2	0.99	0.07
Urban Creek Sediment Heyer	0.27	0.99	0.07
Rooftop asphalt shingles >1 yr old	48	0.86	0.07
Rooftop wooden shingles/shakes, 20 yrs. old	2.9	0.86	0.07
Rooftop asphalt shingles <1 yr old	17.9	0.93	0.07
Rooftop - commercial composite of gravel, tar, wood & asphalt roofs	8.8	0.95	0.07

TABLE I-5. (concluded.)

Sample Description	Median Aspect Ratio (Length/Width)	No. of Fibers Counted for sample	Detection Limit for Sample 10^6 fibers/gram or 10^6 fibers/liter)
Runoff Knox 11/3/79	14.2	40	0.3
Runoff Knox 3/4/80	16.1	41	2.7
Runoff Seaview 3/7/80	17.0	8-10	15.2
Runoff Knox 3/7/80	16.7	38	7.6
Runoff Knox 4/23/80	21.6	25	0.3
Street Dirt Lower 250-600u size	18.3	143	5.8
Street Dirt Middle 600-850u size	16.6	95	4.5
Street Dirt Middle 106-250u size	12.9	112	12
Street Dirt Upper 850-2000u size	16.5	100-105	3.6
Street Dirt Fall 2000-6370u size	29.9	66	1.1
Paved School Playground	21.0	121	6.8
Paved Parking Lot	20.5	46	1.2
Unpaved Parking Lot	21.3	24	1.9
Rural Vacant Lot - 1	18.9	44	1.8
Urban Vacant Lot - 2	19.9	14	7.9
School Turf	18.3	45	16
Rural Creek Sediment Seaview confl.	15.5	20	12
Urban Creek Sediment Heyer	17.8	8	4.8
Rooftop asphalt shingles >1 yr old	15.9	98	20
Rooftop wooden shingles/shakes, 20 yrs. old	16.0	69	4
Rooftop asphalt shingles <1 yr old	15.9	55	21
Rooftop - commercial composite of gravel, tar, wood & asphalt roofs	16.0	48	14